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INSTALLATION RESTORATION PROGRAM
PHASE II-CONFIRMATION/QUANTIFICATION
STAGE 1

For

Minot Air Force Base
Minot, North Dakota

Prepared By:

FRED C. HART ASSOCIATES, INC.
530 Fifth Avenue
New York, NY 10036

October 1988

Volume 1 of 3

Final Report

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION IS UNLIMITED

Prepared For:

HEADQUARTERS STRATEGIC AIR COMMAND
COMMAND SURGEONS OFFICE (HQ SAC/SGPB)
BIOENVIRONMENTAL ENGINEERING DIVISION
OFFUTT AIR FORCE BASE, NEBRASKA 68113

And

UNITED STATES AIR FORCE OCCUPATIONAL &
ENVIRONMENTAL HEALTH LABORATORY (USAFOEHL)
TECHNICAL SERVICES DIVISION (TS)
BROOKS AIR FORCE BASE, TEXAS 78235-5501

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189 2 9 186

ADA204461

REPORT DOCUMENTATION PAGE																
1a. REPORT SECURITY CLASSIFICATION Unclassified		1b. RESTRICTIVE MARKINGS N/A														
2a. SECURITY CLASSIFICATION AUTHORITY N/A		3. DISTRIBUTION/AVAILABILITY OF REPORT UNLIMITED														
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A																
4. PERFORMING ORGANIZATION REPORT NUMBER(S) N/A		5. MONITORING ORGANIZATION REPORT NUMBER(S) N/A														
6a. NAME OF PERFORMING ORGANIZATION Fred C. Hart Assoc., Inc.	6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION USAFOEHL/TSS														
8c. ADDRESS (City, State, and ZIP Code) 530 Fifth Avenue New York, NY 10036		7b. ADDRESS (City, State, and ZIP Code) Brooks AFB, Texas 48235-5501														
9a. NAME OF FUNDING/SPONSORING ORGANIZATION USAFOEHL/TSS	8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F33615-84-D-4404														
8c. ADDRESS (City, State, and ZIP Code) Brooks AFB, Texas 78235-5501		10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. PROJECT NO. TASK NO. WORK UNIT ACCESSION NO.														
11. TITLE (Include Security Classification) Final Report for the Minot Air Force Base, Minot, North Dakota																
12. PERSONAL AUTHOR(S) Fred C. Hart Associates, Inc.																
13a. TYPE OF REPORT FINAL	13b. TIME COVERED FROM 85/9 TO 88/10	14. DATE OF REPORT (Year, Month, Day) 1988, October, 12		15. PAGE COUNT 662												
16. SUPPLEMENTARY NOTATION																
17. COSATI CODES <table border="1"><tr><th>FIELD</th><th>GROUP</th><th>SUB-GROUP</th></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td></tr></table>		FIELD	GROUP	SUB-GROUP										18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) Installation Restoration Program, IRP, Air Force Base, Groundwater Monitoring Wells, North Dakota, hazardous environmental protection, materials.		
FIELD	GROUP	SUB-GROUP														
19. ABSTRACT (Continue on reverse if necessary and identify by block number) In accordance with the procedures developed for the Department of Defense (DOD) Installation Restoration Program (IRP), a Phase II, Stage I site investigation has been performed at the Minot Air Force Base (MAFB), Minot, North Dakota. Fred C. Hart Associates (HART) conducted investigations at three areas of concern at the installation, the Sanitary Landfill Area (SLA), the Firefighting Training Area (FTA) and the Explosive Ordnance Disposal Area (EOD). The investigation of the SLA consisted of the installation and sampling of ground water monitoring wells and of surface water within the SLA. The investigation of the FTA consisted of the installation and sampling of two shallow ground water monitoring wells, the sampling of subsurface soil from a test boring drilled in the center of the FTA and the sampling of surface sediment within the drainage ditch leading away from the FTA. The -continued-																
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION Unclassified													
22a. NAME OF RESPONSIBLE INDIVIDUAL 1Lt Franz J. Schmidt			22b. TELEPHONE (Include Area Code) (512) 536-9001	22c. OFFICE SYMBOL USAFOEHL TSS												

INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION QUANTIFICATION

STAGE 1

FINAL REPORT
FOR

MINOT AIR FORCE BASE
MINOT, NORTH DAKOTA

HEADQUARTERS STRATEGIC AIR COMMAND
COMMAND SURGEON'S OFFICE (HQ SAC/SGPB)
BIOENVIRONMENTAL ENGINEERING DIVISION
OFFUTT AIR FORCE BASE, NEBRASKA 68113

October 1988

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USAF CONTRACT No. F33615-84-D-4404
Delivery Order No. 0008

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Prepared For:

United States Air Force Occupational
and Environmental Health Laboratory (USAFOEHL)
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(CL5060B/0528N)

Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	<input type="checkbox"/>
By _____	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	



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This report has been prepared for the United States Air Force by Fred C. Hart Associates, Inc. for the purpose of aiding in the implementation of the Air Force Installation Restoration Program. It is not an endorsement of any product. The views expressed herein are those of the contractor and do not necessarily reflect the official views of the publishing agency, the United States Air Force or the Department of Defense.

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investigation of the EOD consisted of sampling of subsurface sediment from within a test boring drilled in the center of the EOD. SLA surface water and ground water was found to contain elevated concentrations of common anions and certain metals; however the presence of these constituents is likely to be the result of natural processes and may, therefore, not represent contamination. No significant ground water contamination was detected in the FTA; however, FTA subsurface soil and FTA drainage ditch surface sediment was found to be significantly contaminated by aromatic volatile organic compounds and petroleum hydrocarbons. The FTA investigation was not sufficient to determine the magnitude of contamination nor the rate and direction of movement of FTA contaminants. EOD subsurface soil was found to contain elevated concentrations of cadmium; however, the investigation of the EOD was not sufficient to fully evaluate the presence of cadmium in surface soil. The most significant conclusion to be drawn from the results of this investigation is that MAFB is situated over a geologically secure unit which would minimize migration of identified contaminants. Based upon all available information, HART developed alternatives and recommendations for future investigations at the MAFB.

PREFACE

As requested by the U.S. Air Force Occupational and Environmental Health Laboratory (USAFOEHL), Fred C. Hart Associates, Inc. (HART) has prepared the following IRP Report for Phase II confirmation work at the Minot Air Force Base, Minot, North Dakota. This work was conducted under USAF contract No. F33615-84-D-4404, Task No. 0008 and was in accordance with an EPA- approved work plan. The field investigations discussed in this document were undertaken with the intent to fulfill the requirements of the work efforts requested in USAF's June 1986 Scope of Work, as well as to satisfy the USAF Phase II investigation philosophy.

The following HART personnel were involved with the preparation of this report:

James Mack - Contract Management

Robert Goldman - Project Management, Alternatives, Recommendations

Vanessa DeVillez - Field Program

James Volz - Geology, Hydrogeology, Hazard Assessment, Risk Assessment

Jill Greenberg - Hazard Assessment, Risk Assessment

HART would like to acknowledge the assistance provided by Minot Air Force Base while conducting the investigation and, in particular, thank Captain David DeMay, Bioenvironmental Engineer at Minor Air Force Base (MAFB), for devoting a great deal of his time to coordinating base activities in order to aid the field program.

This work was conducted from October 6 to November 2, 1986. Captain Patrick N. Johnson, of the Technical Services Division, USAF Occupational and Environmental Health Laboratory (USAFOEHL) was the Technical Monitor during the field investigations phase of this project.

Approved,



James P. Mack
Contract Project Manager

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INSTALLATION RESTORATION PROGRAM
PHASE II - CONFIRMATION/QUANTIFICATION
UNITED STATES AIR FORCE
MINOT AIR FORCE BASE

EXECUTIVE SUMMARY

In accordance with the procedures developed for the Department of Defense (DOD) Installation Restoration Program (IRP), a Phase II Confirmation and Quantification site investigation has been performed at Minot Air Force Base (MAFB), Minot, North Dakota.

Environmental Science and Engineering, Inc. (ESE) was retained by the USAF to conduct Phase I of the MAFB IRP. The Phase I investigation identified three areas at MAFB subject to contamination and potential contaminant migration as a result of past waste disposal practices.

As requested by the U.S. Air Force Occupational and Environmental Health Laboratory (USAFOEHL), Fred C. Hart Associates (HART) has prepared the following IRP Report for Phase II confirmation work at MAFB.

A. Background

A.1 Purpose of the Program

The scope of this study was to conduct a contaminant source investigation at MAFB for the purpose of assessing: (1) the presence or absence of contamination within the specified areas of the field survey; (2) the potential for migration of contamination (if found) within the specified areas of the field survey; (3) the extent and magnitude of contamination (if found) on MAFB property; and (4) potential environmental consequences and health risks of migrating contaminants (if found) based on state and federal standards for these contaminants.

A.2 Site History and Potential Sources of Contamination

A.2.a Site History of Hazardous Materials Handling. The major industrial operations at MAFB and its sub-installations relate to the maintenance of aircraft, missiles, ground vehicles and support facilities for the 91st Strategic Missile Wing (SMW), 5th Ballistic Missile Wing (BMW) and the 91st Combat Support Group. Operations include the following: engine repairs and overhauls; electrical, hydraulic and fuel system repairs; painting; metal plating and finishing; missile system maintenance; aircraft maintenance; fuel supply and handling; and additional activities.

The main types of waste generated at MAFB include the following: fuels, oils, solvents, paints and paint strippers, metal plating and treatment solutions and small amounts of explosives and pesticides. Waste fuel (including JP-4 fuel), oil, solvents, engine oil, PD680 and acetone are produced primarily from periodic maintenance and engine repair. The general trend in waste disposal since the establishment of the base has transposed from largely unsegregated disposal in base landfills toward extensive waste segregation and disposal in base landfills and contract disposal.

A.2.b Potential Sources of Environmental Contamination. Three major areas of potential environmental contamination at MAFB were identified in the Phase I - Records Search Report: the Sanitary Landfill Area (SLA), the Firefighting Training Area (FTA) and the Explosive Ordnance Disposal Area (EOD; Figure 1).

The Sanitary Landfill Area is located adjacent to the sewage lagoons in the northwest corner of the base. It was used from the initiation of base operations in 1957 until 1982 for the disposal of domestic and other wastes, including petroleum, oils, lubricants and a variety of potentially hazardous wastes. Authorized disposal at the SLA is currently restricted (CL5061A/1)

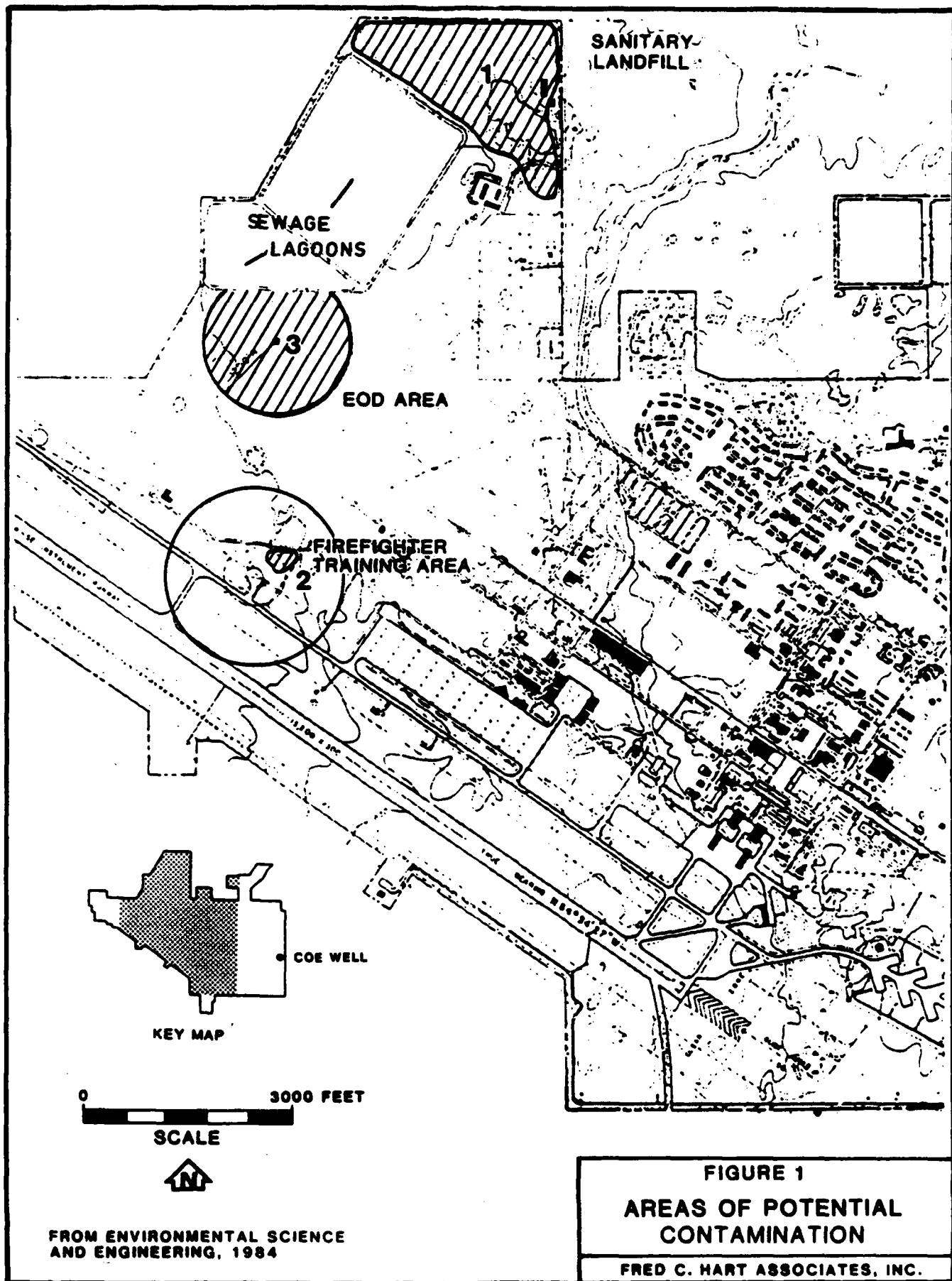


FIGURE 1
AREAS OF POTENTIAL
CONTAMINATION

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to construction rubble, although there is evidence of unauthorized dumping of other materials, such as household furnishings, scrap wood, empty pesticide containers and empty drums (Phase I Records Search, 1984).

An old trench in the SLA has begun to fill with rainwater, snow melt and leachate. Vigorous methane generation was observed in this trench (Phase I Records Search, 1984). The leachate contains metals and phenols and may have originated from garbage and/or hazardous waste placed in the landfill (Phase I Records Search, 1984). MAFB has installed four monitoring wells at this site.

The FTA served as a contaminated fuel and lubricant disposal point for many years. The burn pit was equipped with a drain line which allowed liquids poured into the pit to enter a nearby drainage ditch. Fuels entering the ditch soaked into the ditch bottom or were transported by run-off. Located near the burn pit were oil lagoons used as contaminated fuel and lubricant disposal points. The area was used for oil disposal from early 1960 to around 1972, when the underground tanks at the petroleum, oil and lubricant storage areas were installed. Approximately 2,000 gallons of JP-4 fuel are currently burned each month in training operations.

The EOD is used to burn, explode and bury unserviceable munitions, starter cartridges, flares, impulse cartridges, explosive bolts and explosives. Such operations are conducted approximately once each month. There is a potential for heavy metal and petroleum hydrocarbon contamination within the EOD.

B. Field Program

In compliance with the Technical Operations Plan for Phase II Confirmation and Quantification at MAFB, HART has completed the following tasks:

(CL5061A/1)

B.1 Test Boring Program

To assess the geology underlying MAFB, a soil boring and sampling program was conducted at each of the areas of investigation. Eight test borings were drilled in the SLA, four in the FTA and one in the EOD.

B.2 Monitoring Well Installation

To assess the hydrogeological conditions, as well as the presence and degree of any potential ground water contamination, monitoring wells were installed in the SLA and FTA. Five shallow and four deep monitoring wells were installed in the SLA and two shallow monitoring wells were installed in the FTA (Figures 2 and 3).

B.3 Sediment Sampling Program

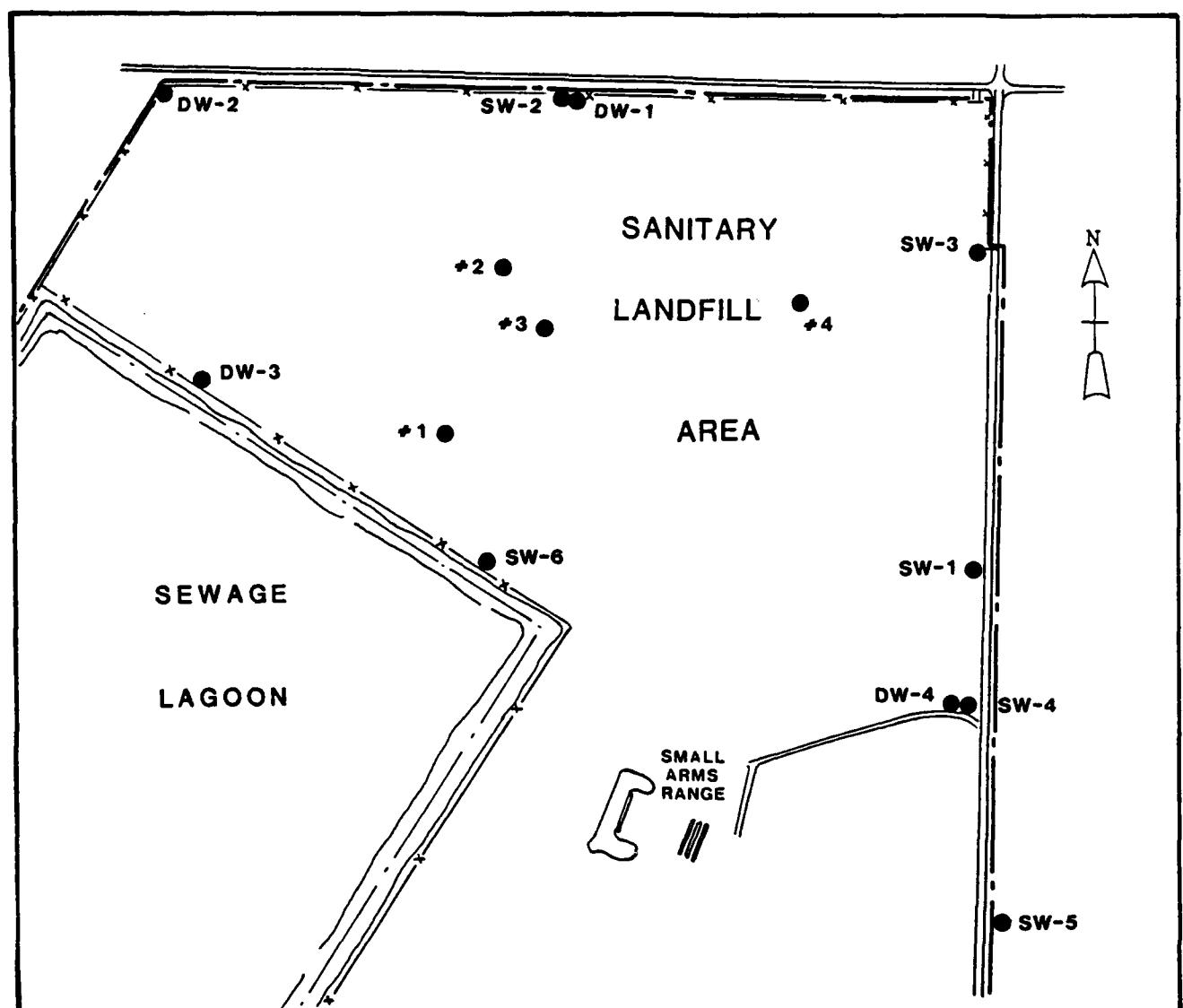
A sediment sampling program was conducted in the drainage ditch leading away from the FTA to assess the presence and extent of any potential contamination of surface sediment as a result of activities related to the FTA.

B.4 Soil Sampling Program

To assess the presence and vertical extent of any potential contamination within the subsurface soil, samples were retained from one test boring in the FTA and from the test boring in the EOD for geochemical analyses.

B.5 Ground Water Sampling Program

To assess the presence and extent of any potential contamination of ground water, field and laboratory analyses were conducted on samples obtained from the nine HART-installed SLA monitoring wells, the four previously installed MAFB landfill wells, the two HART-installed FTA wells and the Corps of Engineers (COE) abandoned water production well.



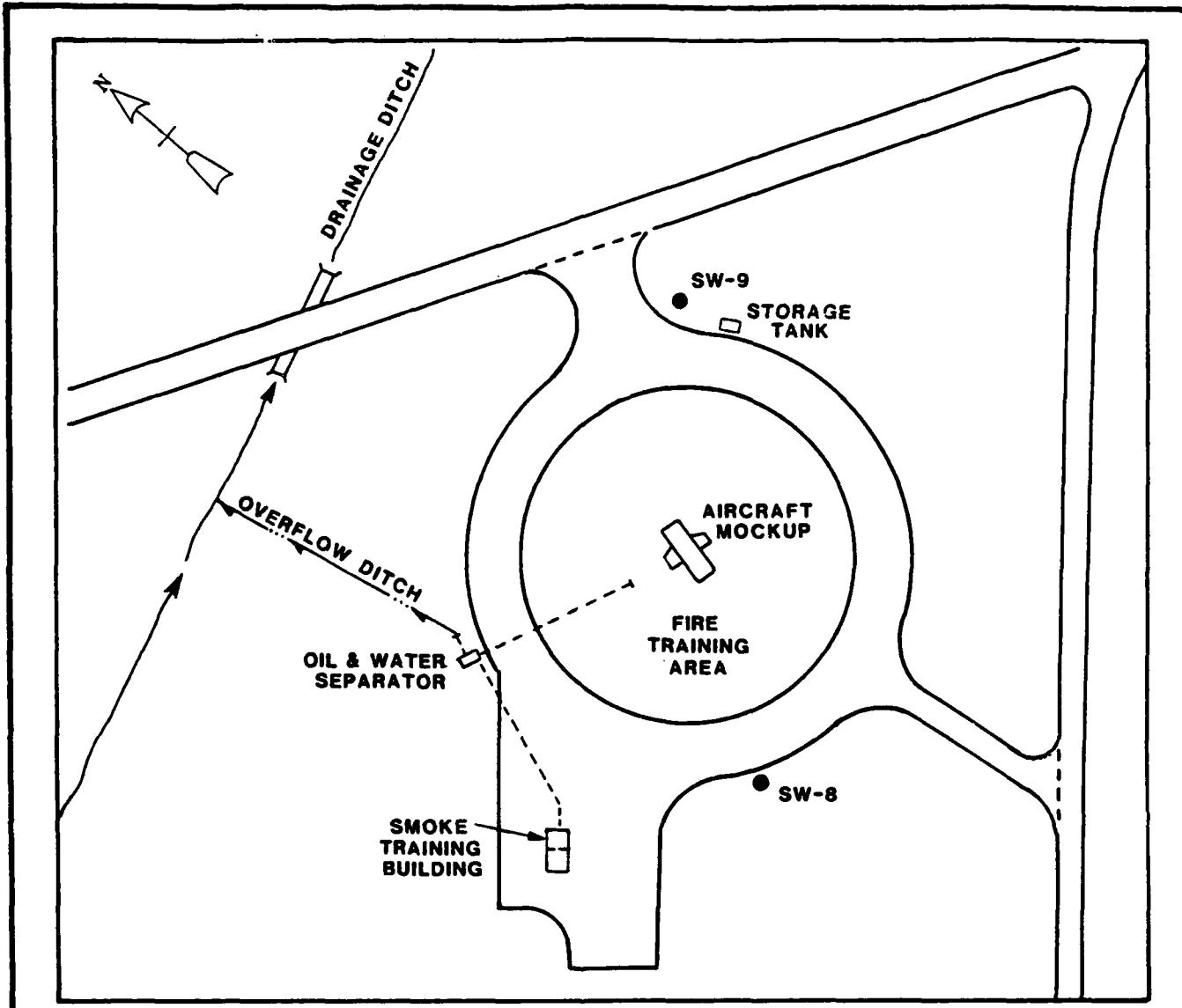
LEGEND

- SW-1 • HART INSTALLED GROUNDWATER MONITORING WELL
- #1 • MAFB INSTALLED GROUNDWATER MONITORING WELL

300 0 600
SCALE (FEET)

FIGURE 2
LOCATIONS OF
MONITORING WELLS IN
THE SANITARY LANDFILL AREA
MINOT AIR FORCE BASE

FRED C. HART ASSOCIATES, INC.



LEGEND

SW-8 • HART INSTALLED GROUNDWATER
MONITORING WELL

50 0 100
SCALE (FEET)

FIGURE 3
LOCATIONS OF MONITORING
WELLS IN THE FIREFIGHTING
TRAINING AREA
MINOT AIR FORCE BASE

FRED C. HART ASSOCIATES, INC.

B.6 Surface Water Sampling Program

To assess the presence and extent of any potential contamination of surface water located within the SLA, field and laboratory analyses were conducted on four samples of this surface water. Samples were obtained from standing water found to be present in several of the shallow depressions and unfilled trenches in the SLA.

B.7 Surveying

The horizontal and vertical location of all HART-installed monitoring wells and the four previously installed MAFB landfill wells were surveyed by a subcontracted professional land surveyor.

C. Environmental Setting

MAFB is situated upon a laterally and vertically extensive ground moraine plain. The ground moraine is a glacial sediment composed almost entirely of till. The till is characterized as an unstratified deposit of sediment with a particle size ranging from clay to boulders. However, clay and silt size particles account for the largest percentage of the sediment volume. The HART boring program confirmed that this till extends to a depth of at least 100 ft beneath MAFB. Deeper borings completed in the vicinity of MAFB (USGS Test Borings, Appendix D) indicate the till extends to depths ranging from 150 to 220 ft. Below that depth, the Paleozoic bedrock surface is encountered. Quaternary glacial sediments rest unconformably upon an irregular Paleozoic bedrock surface.

The only type of deposit other than till present within the glacial sediments is a minor occurrence of glacial sand and gravel. A review of available literature and the HART boring program indicates that these sand and gravel deposits are discontinuous, lenticular and contain a variety of sediment types. These sand and gravel deposits account for less than 5% of the total volume of the first 100 ft of glacial sediments. Generally, (CL5061A/1)

the sand and gravel deposits are scattered throughout the till; however, a small concentration of sand lenses exist at shallow depths along the eastern margin of the SLA.

The ground moraine plain beneath MAFB is part of what is referred to in the literature as the Central Recharge Area. The term Central Recharge Area refers to the process in which water, emanating from precipitation, migrates downward through the glacial sediments to recharge deeper, water-bearing units. Information obtained from HART-installed monitoring wells supports the belief that MAFB is situated within a recharge area. Water levels in HART-installed wells indicate decreasing head with depth and, thus, that the vertical component of ground water movement is downward.

The results of geotechnical sampling during the HART investigation at MAFB indicated the permeability of the glacial till to be approximately 10^{-7} cm/sec, which, in relative terms, is a very low value. This value is commensurate with the permeability values of glacial till reported in the literature. By use of this information and other information obtained during the HART investigation, it was demonstrated that the rate of movement of water downward through this glacial till is in the range of a few centimeters per year.

In an attempt to construct a water table contour map, the water level elevations in the monitoring wells were plotted on a base map to be contoured; however, accurate determinations of the configuration of the surface of the zone of saturation could not be made by this method because till generally yields little or no water to wells despite its degree of saturation. The monitoring wells at MAFB that produce water from the glacial deposits contain sand lenses within the screened interval.

The type of water level contour map that is constructed from hydraulic head measurements is known as a potentiometric surface map. A potentiometric surface map can only be constructed for confined aquifers. The sand lenses contained within the till may be considered confined (CL5061A/1)

aquifers, since they are units of relatively high permeability confined above and below by till of low permeability. However, the concept of a potentiometric surface is only valid for horizontal flow in a continuous, horizontal aquifer (Freeze and Cherry, 1979). The wells at MAFB are receiving water from lenticular and discontinuous sand deposits that cannot be considered a single, horizontal, continuous aquifer. In addition, if there are vertical components of flow, calculations and interpretations based on this type of water level contour map can be very misleading (Freeze and Cherry, 1979). It has already been established that a vertical component of ground water flow is present in the glacial sediment underlying MAFB. Thus, calculations and interpretations regarding the direction and rate of ground water flow based on a potentiometric surface map (or water level contour map for confined sand lenses) would likely be in error.

D. Discussion of Results and Significance of Findings

D.1 The Sanitary Landfill Area Sampling Program and Results

The sampling plan for the SLA included ground water and surface water sampling. Water samples were field tested for pH, conductivity and temperature and were laboratory analyzed for total petroleum hydrocarbons (TPH), extractable priority pollutant organics, 13 priority pollutant metals, total dissolved solids and common anions.

D.1.a Surface Water. Of the common anions analyzed, all were found to be present in concentrations above the detection level (ADL) in at least one of the surface water samples. Sulfate was the dominant anion in these samples, accounting for approximately 90% of the total concentration of common anions. Surface water samples contained concentrations of common anions ranging from 1,533 to 3,553 milligrams per liter (mg/l). Of the 13 priority pollutant metals, zinc, copper and nickel were found in ADL concentrations in the surface water samples. Total petroleum (CL5061A/1)

hydrocarbons, aromatic and halogenated volatile organic compounds and extractable priority pollutant organics were not found in ADL concentrations in any of the surface water samples.

D.1.b Ground Water. Of the 13 priority pollutant metals, only copper, nickel, lead, zinc and silver were found in ADL concentrations. Zinc was the only metal found in ADL concentrations in 100% of the ground water samples. Nitrite nitrogen was the only common anion analyzed for that was not found in ADL concentrations in any of the ground water samples. Chloride, fluoride and sulfate were present in ADL concentrations in 100% of the ground water samples. The total common anion concentrations of individual samples ranged from 711 to 6,438 mg/l. Total dissolved solids concentrations of the ground water samples varied from 1,280 to 9,440 mg/l and averaged 3,880 mg/l. Total petroleum hydrocarbons were only detected in ADL concentrations in one ground water sample. Aromatic and halogenated volatile organic compounds and extractable priority pollutant organics were not found in ADL concentrations in any of the ground water samples.

D.2 FTA Sampling Program and Results

The sampling plan for the FTA included ground water, subsurface soil and surface sediment sampling. Ground water samples were field tested for pH, conductivity and temperature. All soil, surface sediment and ground water samples were laboratory analyzed for aromatic and halogenated volatile organic compounds, TPH and lead.

D.2.a Ground Water. In one of the two FTA wells, five different halogenated volatile organic compounds were found in ADL concentrations ranging from 2 to 11 micrograms liter (ug/l). A duplicate analyses

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performed on this sample confirmed the presence of these compounds. One sample contained TPH at the detection level. Lead and aromatic volatile organic compounds were not detected in ADL concentrations in any of the ground water samples.

D.2.b Subsurface Soil. Total petroleum hydrocarbons and lead were found in ADL concentrations in all four subsurface soil samples. Concentrations ranged from 13 to 780 milligrams per kilogram (mg/kg) for TPH and from 2.34 to 4.28 mg/kg for lead. Three out of four subsurface soil samples contained variable amounts of the following aromatic volatile organic compounds: toluene, chlorobenzene, ethylbenzene, 1,2-1,3-dichlorobenzene and 1,4-dichlorobenzene. Confirmatory analyses verified the presence of these compounds in soil samples. Detected concentrations of aromatic volatile organics ranged from 300 to 3,800 micrograms per kilogram (ug/kg) for individual samples. Halogenated volatile organic compounds were not detected in any of the subsurface soil samples.

D.2.c Surface Sediment. Total petroleum hydrocarbons and lead were found in ADL concentrations in all four sediment samples. The concentrations of TPH ranged from 350 to 16,550 mg/kg and the concentrations of lead ranged from 1.33 to 12.20 mg/kg. Surface sediment samples contained variable amounts of the following seven aromatic volatile organic compounds: benzene, toluene, chlorobenzene, ethylbenzene, 1,4-dichlorobenzene and 1,2-1,3-dichlorobenzene. Halogenated volatile organic compounds were not detected in any of the sediment samples.

D.3 EOD Sampling Program and Results

The sampling plan for the EOD area consisted of laboratory analyses of subsurface soil samples for TPH and priority pollutant metals. Chromium, copper, nickel, lead, zinc and silver were detected in all of the subsurface soil samples; cadmium was detected in two of the three subsurface soil samples; and mercury was detected in one of three subsurface soil samples. Total petroleum hydrocarbons were not found in ADL concentrations in any of the subsurface soil samples.

D.4 SLA: Significance of Findings

The results of the sample analyses indicate that surface water and ground water within the SLA contained the following constituents in ADL concentrations in at least one sample: copper, nickel, zinc, lead, silver, chloride, fluoride, bromide, nitrate nitrogen, nitrite nitrogen, phosphate, sulfate and TPH.

With the exception of petroleum hydrocarbons, all of the constituents detected in SLA surface water and ground water samples are substances which commonly occur naturally in water. For this reason, their presence does not necessarily indicate the existence of contamination. The North Dakota State Department of Health has not adopted federal secondary drinking water standards which have been established for copper, zinc, chloride, sulfate and TDS because the state has recognized that natural mineralization of ground water within the state may, and commonly does, result in concentrations of these substances which exceed established standards. A comparison of the range of detected concentrations for constituents in SLA surface water with all available water quality criteria is presented in Table 1. A comparison of the range of detected concentrations for constituents found in SLA ground water with all available water quality criteria is presented in Table 2.

TABLE 1

COMPARISON OF SLA SURFACE WATER SAMPLING RESULTS WITH
AVAILABLE FEDERAL AND STATE WATER QUALITY CRITERIA

<u>Detected Constituent</u>	<u>Range of Concentrations</u> mg/l	<u>NIPDWSS-1</u> mg/l	<u>NSDWSS-2</u> mg/l	<u>RMCLs-3</u> mg/l	<u>PPCLs-4</u> mg/l	<u>NDWQSS-5</u> mg/l	<u>EPAMWQC-6</u> mg/l
Priority Pollutant Metals							
Copper	BDL-0.04	-	1.0	1.30 ^a	-	0.05	1.0
Nickel	BDL-0.097	-	-	0.75(ADI); 0.00003 (UCR)	-	-	0.0134
Zinc	0.03-0.22	-	5.0	-	7.5(ADI)	1.0	5.0
Common Anions							
Chloride	50-400	-	250	-	-	100	-
Flouride	1.3-1.6	2.0	-	-	-	-	-
Bromide	1.8-311	-	-	-	-	-	-
Nitrate	0.21-1.05	10.0	-	10.0 ^a	-	-	1.0
Nitrite	BDL-0.1	-	-	1.0 ^a	-	-	-
Phosphate	BDL-0.96	-	-	-	-	-	0.1
Sulfate	1100-3500	-	250	-	-	250	-
Total Dissolved Solids	2596-4782	-	500	-	-	-	-

Legend

- 1 - National Interim Primary Drinking Water Standards; USEPA 40CFR141.
 - 2 - National Secondary Drinking Water Standards; USEPA 40CFR143.
 - 3 - Recommended Maximum Contaminant Levels; USEPA 40CFR141.
 - 4 - Preliminary Protective Concentration Limits for 40CFR261, Appendix VIII "Hazardous Constituents" where:
- ADI = Acceptable Daily Intake
MCL = Maximum Concentration Level
UCR = Unit Cancer Risk (based on a 10⁻⁶ incremental increase in risk of cancer)
5 - North Dakota Water Quality Standards; North Dakota Department of Health Rule 33-16-02, Section 06.
6 - USEPA Ambient Water Quality Criteria; Federal Register, Vol. 45, No. 231, 11/28/80.
a - Proposed RMCLs, Federal Register, Vol. 50, No. 261, 11/13/85, pg. 47022.
- No standard established.
BDL - Below Detection Level.
mg/l - milligrams per liter

(CL5022B/1)

TABLE 2

COMPARISON OF SLA GROUND WATER SAMPLING RESULTS WITH
AVAILABLE FEDERAL AND STATE WATER QUALITY CRITERIA

<u>Detected Constituent</u>	<u>Range of Concentrations</u> mg/l	<u>NIPDOS¹</u> mg/l	<u>NSDASS²</u> mg/l	<u>NCCLS³</u> mg/l	<u>PPCL⁴</u> mg/l	<u>NDMASS⁵</u> mg/l	<u>EPAAMR⁶</u> mg/l
Priority Pollutant Metals							
Copper	BDL-0.59	-	1.0	1.30 ^a	-	-	0.05
Nickel	BDL-0.43	-	-	-	0.75(ADI); 0.15(ADI); 0.05(UCR)	-	0.0134
Lead	BDL-0.17	0.05	-	0.02 ^a	0.05(UCR)	0.05	0.05
Zinc	0.02-1.67	-	5.0	-	7.5(ADI)	1.0	5.0
Silver	BDL-0.02	0.05	-	-	0.05(NCL)	-	0.05
Common Anions							
Chloride	10-150	-	250	-	-	100	-
Fluoride	0.38-1.20	2.0	-	-	-	-	-
Bromide	BDL-4.3	-	-	-	-	-	-
Nitrate	BDL-2.20	10.0	-	10.0 ^a	-	-	1.0
Phosphate	BDL-19.2	-	-	-	-	-	0.1
Sulfate	700-6300	-	250	-	-	-	250
Total Dissolved Solids	1280-9440	-	500	-	-	-	-
Total Petroleum Hydrocarbons	0.80	-	-	-	-	-	-

Legend

- 1 - National Interim Primary Drinking Water Standards; USEPA 40 CFR 141.
- 2 - National Secondary Drinking Water Standards; USEPA 40 CFR 143.
- 3 - Recommended Maximum Contaminant Levels; USEPA 40 CFR 141.
- 4 - Preliminary Protective Concentration Limits for 40 CFR 261, Appendix VIII "Hazardous Constituents" where:

ADI = Acceptable Daily Intake

NCL = Maximum Concentration Level

UCR = Unit Cancer Risk (based on a 10^{-6} incremental increase in risk of cancer)

5 - North Dakota Water Quality Standards; North Dakota Department of Health Rule 33-16-02, Section 06.

6 - USEPA Ambient Water Quality Criteria; Federal Register, Vol. 45, No. 231, 11/28/80.

a - Proposed NCCLS, Federal Register, Vol. 50, No. 261, 11/13/85, pg. 47022.

- No standard established.

BDL - Below Detection Level.

mg/l - milligrams per liter

The elevated concentrations of sulfate, chloride and nickel in SLA surface water are believed to be the result of two processes. First, SLA surface water is mineralized through contact with the weathered, surface glacial till sediments. Second, evaporation of surface water results in the concentration of these constituents in surface water bodies. The elevated concentrations of all constituents detected in SLA ground water, except petroleum hydrocarbons, are believed to be the result of mineralization of the ground water through contact with glacial till sediments. Petroleum hydrocarbons were only detected in one ground water sample in a very low concentration. For this reason, it is very difficult to determine if the presence of petroleum hydrocarbons in one ground water sample represents significant contamination.

D.5 FTA: Significance of Findings

The results of sample analyses indicate that FTA ground water contained HVOs and TPH in ADL concentrations and FTA subsurface soil and surface sediment contained AVOs, TPH and lead in ADL concentrations.

Two important conclusions can be made regarding the constituents detected in FTA ground water. First, no constituents were detected in FTA ground water which exceeded any applicable or enforceable water quality criteria (Table 3). Second, where water quality criteria were available, the detected concentrations of constituents in FTA ground water were at least one order of magnitude below the established criteria. Thus, on the basis of all available information, it is reasonable to conclude that the samples obtained from FTA ground water were not significantly contaminated with respect to the parameters analyzed. However, due to the discontinuous nature of the water-bearing sand and gravel deposits encountered at MAFB, it is not possible to state, based on the information presently available, that no significant contamination of FTA ground water has occurred.

TABLE 3

COMPARISON OF FTA GROUND WATER SAMPLING RESULTS WITH
AVAILABLE FEDERAL AND STATE WATER QUALITY CRITERIA

<u>Detected Constituent</u>	<u>Range of Concentration</u> ng/l	<u>NIPNS's¹</u> ng/l	<u>MCL's²</u> ng/l	<u>PPCL's³</u> ng/l	<u>EPA DHAR⁴</u> ng/l	<u>SNARL's⁵</u> ng/l	<u>EPA/HRC</u> ng/l
Halogenated Volatile Organics							
1,2-Dichloroethane	BDL-0.011	5.0; 0.005 ^a	0.0	0.0005(UCR); 0.00095(UCR)	0.740 (1-day, 10-day + chronic)	-	0.0009
1,1,1-Trichloroethane	BDL-0.011	0.20 ^a	0.20	19.0(ADL); 0.022(UCR)	140.0 (1-day); 35 (10-day + chronic)	1.0 ^b	0.0184
Bromodichloromethane	BDL-0.003	0.10	-	0.019(ADL)	-	-	0.0001
Trichloroethene	BDL-0.004	0.005 ^a	-	-	-	-	0.0027
Tetrachloroethene	BDL-0.002	-	-	-	34.0 (10-day); 1.94 (chronic)	-	0.0008
Total Petroleum Hydrocarbons	BDL-0.50	-	-	-	-	-	-

Legend

- 1 - National Interim Primary Drinking Water Standards; USEPA 40 CFR 141.
 - 2 - Recommended Maximum Contaminant Level; USEPA 40 CFR 141.
 - 3 - Preliminary Protective Concentration Level for 40 CFR 261, Appendix VIII "Hazardous Constituents" where:
- ADL = Acceptable Daily Intake
- MCL = Maximum Concentration Level
- UCR = Unit Cancer Risk (based on a 10^{-6} incremental increase in concern risk)
- 4 - EPA Drinking Water Health Advisories for a 10 kg infant
 - 5 - USEPA Suggested No Adverse Response Levels.
 - 6 - USEPA Ambient Water Quality Criteria; Federal Register, Vol. 45, No. 231, 11/28/80.
- a - Proposed MCL, Federal Register, Vol. 50, No. 261, 11/13/85, pg. 47022.
- b - SNARL Set for Chronic Exposure Response.
- No Standard Established.
- ng/l - milligrams per liter

A single test boring (TB-1) was completed in the center of the FTA to obtain subsurface soil samples for chemical analyses. Four samples were sent for analyses. The results of analyses indicate the following: 1) TPH was found in all samples in concentrations ranging from 13 to 780 mg/kg; 2) no HVO compounds were found in ADL concentrations in any of the samples; and 3) lead was found in all samples in concentrations ranging from 2.34 to 4.28 mg/kg. It is not possible to make accurate determinations regarding the horizontal and vertical distribution of contaminants in FTA subsurface soil from information obtained from a single test boring. It appears that contamination of subsurface soil at the test boring location is significantly reduced beyond the depth of 17 ft. The subsurface soil sample obtained from the 15 to 17-ft interval contained total petroleum hydrocarbons with a concentration of 290 mg/kg and AVO compounds with concentrations ranging from 0.45 to 3.80 mg/kg. The subsurface soil sample obtained from the 20 to 22-ft interval contained petroleum hydrocarbons in a concentration of 13 mg/kg and did not contain any detectable AVO compounds. It is not possible to determine if this interval represents a point of significant decrease in contamination throughout the FTA.

Surface sediment samples were obtained from three locations in the FTA drainage ditch for chemical analyses. The analyses results indicate the following: 1) petroleum hydrocarbons were found in all samples in concentrations ranging from 350 to 16,550 mg/kg; 2) lead was found in all samples in concentrations ranging from 1.33 to 12.20 mg/kg; 3) no HVO compounds were detected in ADL concentrations; and 4) all of the AVO compounds were found in ADL concentrations ranging from 0.1 to 12.0 mg/kg.

It is not possible to make accurate determinations regarding the vertical and lateral distribution of contaminants based on the limited sampling conducted within the FTA drainage ditch. The lateral extent of contamination has been determined to a limited extent; however, determination of the vertical distribution of contaminants is not possible as sampling was limited to depths of 0 to 12 inches.

The contaminants present in FTA subsurface soil are essentially immobile. As previously demonstrated, the permeability of the glacial till underlying MAFB is very low and ground water movement is downward at the approximate rate of 1 foot per 10 years. Although higher concentrations of contaminants than those detected in ground water in the FTA may exist, the ground water migration rate is significantly low to prevent widespread contaminant migration. No significant water bearing sand and gravel units exist within the glacial sediments within 5 miles of MAFB and bedrock is known to be at a depth of at least 100 ft. Thus, the potential for FTA contaminants to pollute a water supply is minor. The potential for human exposure to contaminated subsurface soil or ground water is also minor.

The contaminants present within the FTA drainage ditch are essentially at the surface and, thus, there is the potential for human exposure. Human exposure could occur by contact with in-situ sediments or by contact with airborne particles.

D.6 EOD Area: Significance of Findings

The results of the analyses indicate that TPH are not present in ADL concentrations and that, of the 13 Priority Pollutant metals analyzed for, only cadmium, chromium, copper, nickel, lead, zinc, silver and mercury were present in ADL concentrations.

Comparison of the results of EOD subsurface soil chemical analyses to the trace element content of natural soils indicates the following: 1) the metals chromium, copper and nickel were present in concentrations which were below the average trace element content of natural soils; 2) cadmium concentrations exceeded the average trace element content and the common range in natural soil; and 3) lead, zinc, silver and mercury were present at levels that fall within the common range of each elements' content in natural soil.

No background data are available on the trace element content in soils native to MAFB; thus, all interpretations must be based upon comparison with the average trace element content of natural soils. This comparison indicated that the only metal detected in unusually high concentrations in EOD subsurface soil was cadmium. Cadmium concentrations may represent minor contamination of subsurface soil.

E. Recommendations

The results of the Phase II investigation are conclusive and have provided HART with an adequate data base by which the SLA, the FTA and the EOD can be categorized. The categorization rationale is based on human health and environmental hazards and has been established under the DOD/IRP report format.

Category II sites are those requiring additional monitoring or work to quantify or further assess the extent of current or future contamination. All three sites at the MAFB have been classified in this category.

E.1 The Sanitary Landfill Area

HART's investigation of the SLA was very thorough in scope. It included drilling a total of 10 test borings, installation of 6 shallow and 4 deep monitoring wells, sampling 13 ground water monitoring wells and 4 surface water sites, chemical analyses of water samples for a large variety of parameters and geotechnical analyses of subsurface soil samples.

Long-term monitoring is recommended for the SLA and would consist of sampling the wells installed during HART's investigation and analyzing the samples for a reduced parameter list. Based on the contaminants identified in Chapter IV, a suite of parameters would be chosen to monitor for changes in ground water quality. Parameters that best characterize the present constituents found in the ground water, that could be (CL5061A/1)

indicators of contamination, would include common anions and Priority Pollutant metals. Upon initiation of a ground water monitoring program, semi-annual sampling of the wells would be adequate for the SLA.

E.2 The Firefighting Training Area

The Phase II investigation of the FTA conducted by HART indicated the presence of contamination of surface sediment in the FTA drainage ditch and of subsurface soil beneath the FTA. In addition, although no significant contamination of ground water was found, some contaminants were detected in the ground water sample obtained from monitoring well SW-9 and, thus, there is a potential for ground water contamination.

The Phase II investigation of the FTA conducted by HART was sufficient to determine the presence of contamination in the FTA and FTA drainage ditch; however, this investigation was not sufficient to determine the magnitude, extent, rate of movement and direction of movement of contaminants within the FTA and FTA drainage ditch. Thus, a more intensive Phase II effort is needed to improve the data base on which remedial action will be eventually based.

As stated in Chapter IV of this report, there is no potential for human exposure to contaminated subsurface soil or ground water in the FTA based on the non-existence of drinking water supply or ground water discharge point within a five mile radius of MAFB. However, the potential for human exposure to the FTA drainage ditch contaminants is moderate based on the exposure of the contaminants to the air and the surface water which occasionally flows in this ditch. HART believes that further contamination of this drainage ditch will only increase this potential for exposure and, thus, this situation requires attention.

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E.3 The Explosive Ordnance Disposal Area

It is HART's opinion that the greatest potential for metals contamination exists at the surface of the EOD, where munitions were exploded. The Phase II investigation of the EOD involved only subsurface soil sampling and, thus, additional sampling is required to characterize the presence and extent of surface soil contamination. Further investigation at this site would consist of taking grab samples of the surface soil and analyzing them for Priority Pollutant metals. In order to compare the metals concentrations in the EOD soil samples, a background sample should be taken from outside the EOD in an area free from human disturbances.

I. INTRODUCTION

A. Mission of Air Force Installation Restoration Program (IRP)

The United States Air Force (USAF) has long been engaged in a wide variety of operations that require the storage, use and disposal of toxic and hazardous materials. Federal, state and local governments have developed strict regulations requiring disposers to identify the location and contents of past hazardous waste disposal sites and, when necessary, act to eliminate any hazards to the environment or human health. The primary federal legislation governing the management and disposal of hazardous waste is the amended Resource Conservation and Recovery Act (RCRA). Under Section 6003 of RCRA, federal agencies are directed to assist the Environmental Protection Agency (EPA) in carrying out this Act and must make available all information concerning past and present waste management practices of leased, owned or operated hazardous waste facilities. Federal legislation providing for liability, compensation, cleanup and emergency response of hazardous substances released into the environment is the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, as revised. Under Section 120 of this Act, all federal entities are subject to and must comply with this Act in the same manner and to the same extent as any non-governmental entity. To assure compliance with this and other legislation, the Department of Defense (DOD) developed the Installation Restoration Program (IRP). The current DOD/IRP policy is contained in the Defense Environmental Quality Program Policy Memorandum (DEQPPM) 81-5, dated 11 December 1981 and implemented by Air Force message dated 21 January 1982. DOD/IRP policy is to identify and evaluate suspected problems associated with the past handling of hazardous materials and to remediate environmental contamination that has resulted from these operations.

B. Purpose of Program

The scope of this study is to conduct a contaminant source investigation at Minot Air Force Base (MAFB) located in Minot, North (CL5065A/1)

Dakota for the purpose of assessing: 1) the presence, or absence, of contamination within the specified areas of the field survey; 2) the potential for migration within the specified areas of the field survey; 3) the extent and magnitude of contamination on MAFB property, if present; and 4) potential environmental consequences and health risks of migrating contaminants (if found) based on state and federal standards for these contaminants. This report evaluates the results of the field investigation conducted by HART and incorporates available historic data.

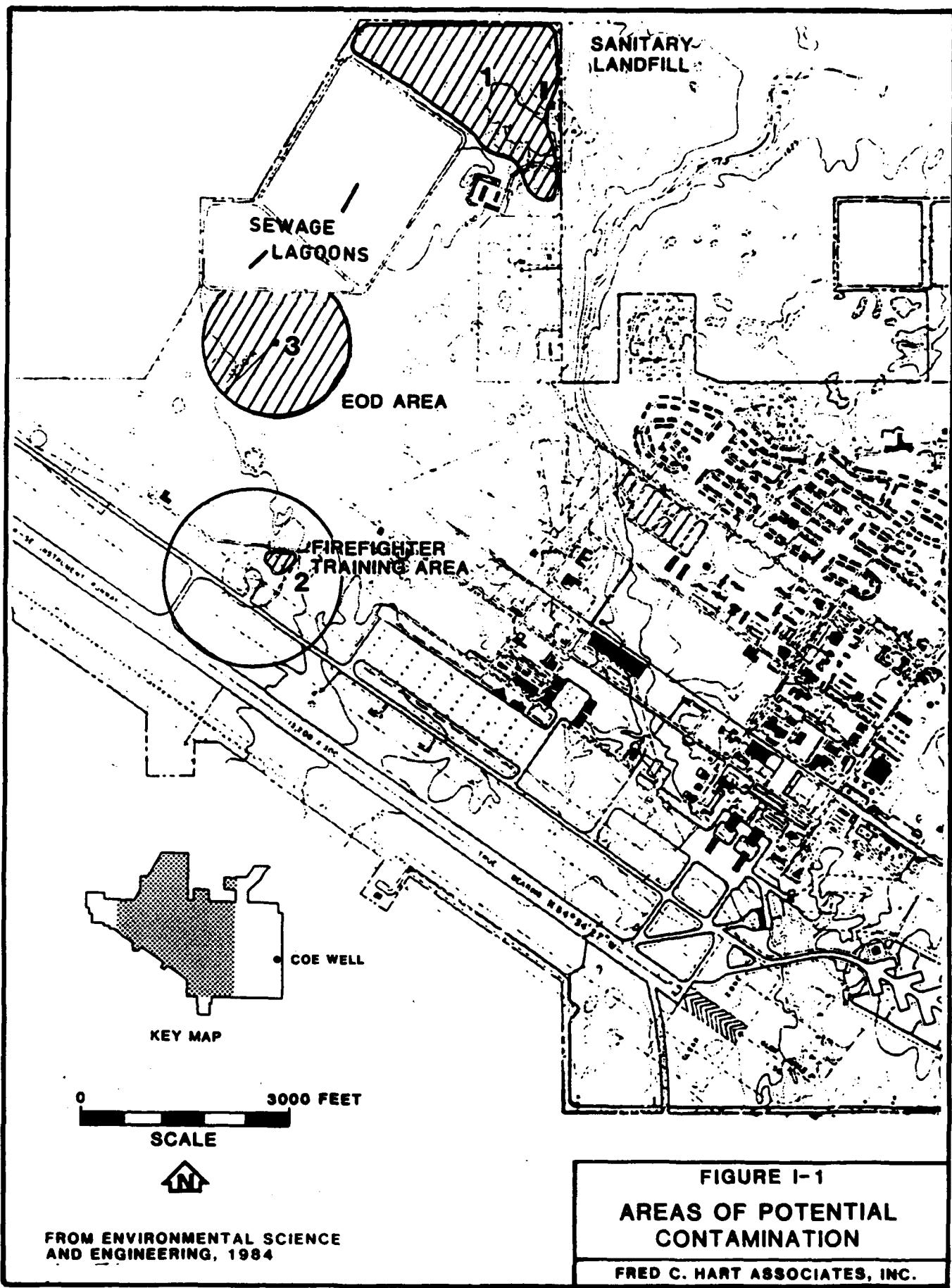
The IRP was originally developed as a four-phase program (the IRP is now EPA Remedial Investigation/Feasibility Study based), as follows:

- Phase I - Initial Assessment/Records Search
- Phase II - Confirmation and Quantification
- Phase III - Technology Base Development
- Phase IV - Operations/Remedial Actions

Environmental Science and Engineering, Inc. (ESE) was retained by the USAF to conduct Phase I of the MAFB IRP. The objective of Phase I was to identify the potential for environmental contamination resulting from past waste disposal practices at MAFB and its subinstallations, and to assess the potential for contaminant migration. Activities performed in the Phase I study included the following: a review of site records; interviews with personnel familiar with past generation and disposal activities; determination of quantities and locations of current and past hazardous waste treatment, storage and disposal facilities; performance of field inspections; and development of conclusions and recommendations. The Phase I investigation identified three areas on MAFB subject to contamination and potential contaminant migration as a result of past waste disposal practices. These three areas are shown on Figure I-1.

B.1 Area 1 - Sanitary Landfill

The base landfill, located adjacent to the sewage lagoons in the northwest corner of the base, was used from initiation of base opera-
(CL5065A/1)



tions in 1957 until 1982 for the disposal of domestic and other wastes, including petroleum products, oils, lubricants and a variety of potentially hazardous wastes. Authorized disposal at the landfill is currently restricted to construction rubble, although there is evidence of unauthorized dumping of other materials, such as household furnishings, scrap wood, empty pesticide containers and empty drums.

An old trench in the landfill has begun to fill with rainwater, snowmelt and leachate. Vigorous methane generation has been observed in this trench (Phase I Records Search, 1984). The leachate contains metals and phenols which may have originated from garbage and/or hazardous waste placed in the landfill (Phase I Records Search, 1984). MAFB has installed four ground water monitoring wells at this site.

B.2 Area 2 - Firefighting Training Area

The Fire Protection Branch training area served as a contaminated fuel and lubricant disposal point for many years. The old burn pit was equipped with a drain line that allowed liquids poured into the pit to enter a nearby drainage ditch. Fuels entering the ditch soaked into the ditch bottom or were transported as run-off. Located near the burn pit were oil lagoons used as contaminated fuel and lubricant disposal points. The area was used for oil disposal from early 1960 to around 1972 when underground tanks at the petroleum, oil and lubricant storage areas were installed. Approximately 2,000 gallons of JP-4 are currently burned each month in this area during training operations.

B.3 Area 3 - Explosive Ordnance Disposal (EOD) Range

The EOD Range (hereafter EOD) is used to burn, explode and bury unserviceable munitions, starter cartridges, flares, impulse cartridges, explosive bolts and other types of explosives. Such operations are conducted approximately once each month. Due to the activities conducted in the EOD, there is potential for heavy metal contamination.
(CL5065A/1)

Additionally, a construction contractor used the EOD briefly as a staging area and, therefore, a potential for unreported fuel spills exists (Technical Operations Plan, Appendix L). For this reason, a potential for petroleum hydrocarbon contamination exists.

As requested by the U.S. Air Force Occupational and Environmental Health Laboratory (USAFOEHL), Fred C. Hart Associates, Inc. (HART) has prepared the following IRP Report for Phase II confirmation work at MAFB. The purpose of this study is to conduct a contaminant source investigation at MAFB to determine: (1) the presence, or absence, of contamination within the specified areas of the field survey; (2) the potential for contaminant migration within the specified areas of the field survey; (3) the extent and magnitude of contamination (if found) on MAFB property; and (4) potential environmental consequences and health risks of migrating contaminants (if found) based on state and federal standards for these contaminants.

The field investigation performed by HART in fulfillment of the Phase II Confirmation and Quantification investigation was based on the Phase II Technical Operations Plan (Appendix L) prepared by HART in September 1986. The Technical Operations Plan provides a detailed operations and sampling plan for field activities. The Technical Operations Plan was based on review of several documents, including: Phase I Records Search (ESE, December 1984); Soil Investigation, Drainage Ditch "A" (Soil Investigation Co., 1974); assorted data provided by U.S. Air Force personnel at the Minot Base; and data gathered during a site visit conducted by HART personnel on October 29, 1985. Due to the nature of the geology encountered during the field investigation, it was necessary to make some changes in the originally proposed Technical Operations Plan (TOP). However, all of the these changes were agreed upon by USAFOEHL personnel and were consistent with USEPA recommendations.

C. Duration of the Program

In compliance with the Technical Operations Plan for the Phase II Confirmation and Quantification investigation at MAFB, HART has completed the following tasks:

C.1 Test Boring Program

To assess the geology underlying MAFB, a soil boring and sampling program was conducted at each of the areas of investigation. Eight test borings were drilled in the Sanitary Landfill Area (SLA), four in the Firefighting Training Area (FTA), and one in the Explosive Ordnance Disposal Area (EOD).

C.2 Ground Water Monitoring Well Installation

To assess the hydrogeological conditions, as well as the presence and degree of any potential ground water contamination, monitoring wells were installed in the SLA and FTA. Five shallow and four deep monitoring wells were installed in the SLA and two shallow monitoring wells were installed in the FTA.

C.3 Sediment Sampling Program

A surface sediment sampling program was conducted in the drainage ditch leading away from the FTA to assess the presence and extent of any potential contamination resulting from activities conducted within the FTA.

C.4 Soil Sampling Program

To assess the potential presence and vertical extent of contamination of subsurface soils, samples were retained from one test boring in the FTA and from one test boring in the EOD for chemical analyses.

C.5 Ground Water Sampling Program

To assess the potential presence and extent of contamination of ground water, field and laboratory analyses were conducted on samples obtained from the nine HART-installed landfill wells, the four previously installed MAFB landfill wells, the two HART-installed FTA wells, and the Corps of Engineers (COE) abandoned water production well.

C.6 Surface Water Sampling Program

To assess the potential presence and extent of contamination of surface water located within the SLA, field and laboratory analyses were conducted on surface water samples collected from four locations within the SLA.

C.7 Surveying

The horizontal and vertical location of all HART-installed monitoring wells and the four previously installed MAFB landfill wells were surveyed by a subcontracted professional land surveyor.

The above tasks were completed by HART over the time period from October 6 to November 2, 1986. Figure I-2 outlines the time frame during which these and related tasks were completed. Details of the tasks can be found in Section III of this report, entitled Field Program.

D. History of Operation at MAFB and Description of Potential Sources of Environmental Contamination

D.1 History of Operation

The first portions of land for the base were purchased in 1955 and the first buildings were constructed about two years later. The Aerospace Defense Command (ADCOM) 32nd Fighter Wing was activated in February 1957, (CL5065A/1)

FIGURE I-2

SCHEDULE OF COMPLETED TASKS**FIELD INVESTIGATION DATES (1986)**

TASK	10/6	10/7	10/8	10/9	10/10	10/11	10/12	10/13	10/14	10/15	10/16	10/17	10/18	10/19	10/20	10/21	10/22	10/23	10/24	10/25	10/26	10/27	10/28	10/29	10/30	10/31	11/1	11/2	
ON-SITE MEETING HART-USAFOEHL														X															
SLA TEST BORING PROGRAM														X	X														X
FTA TEST BORING PROGRAM														X	X														X
EOD TEST BORING PROGRAM														X	X														X
SLA MONITORING WELL INSTALLATION																													X
FTA MONITORING WELL INSTALLATION																													X
MONITORING WELL DEVELOPMENT PROGRAM																													X
GROUNDWATER SAMPLING PROGRAMS (SLA,FTA,COE)																													X
FTA SUBSURFACE SOIL SAMPLING PROGRAM																													X
EOD SUBSURFACE SOIL SAMPLING PROGRAM																													X
FTA SURFICIAL SEDIMENT SAMPLING PROGRAM																													X
SLA SUBSURFACE WATER SAMPLING PROGRAM																													X
WATER LEVEL MEASUREMENTS																													X
SURVEYING																													X

X = No Field Work

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and the following year the Strategic Air Command (SAC) 4136th Strategic Wing, with KC-135 "Strato-tankers," was assigned as a tenant unit. B-52 "Strato-fortress" bombers were added to the SAC Wing's inventory in 1961. Two years later, the 4136th was redesignated the 450th Ballistic Missile Wing (BMW). The first housing units opened in October 1960. Since this time, the MAFB housing area has become one of the largest in the Air Force with approximately 2,500 family units.

The transfer of the base from ADCOM to SAC occurred in 1962 in conjunction with the arrival of the 810th Strategic Aerospace Division from Biggs Air Force Base (AFB), Texas. With this division came the activation of the 455th Strategic Missile Wing (SMW) and a Combat Support Group. By 1964, all 150 Minuteman intercontinental ballistic missile launch facilities were completed and the last of the Minuteman I missiles were in place.

In June 1968, the 455th SMW was redesignated the 91st SMW, and one month later, the 450th BMW became the 5th BMW. John Moses Hospital, located in downtown Minot and which the Air Force took over from the Veterans Administration in 1959, became a USAF Regional Hospital in July 1969.

In July 1971, the 91st SMW's 741st Strategic Missile Squadron became the first Minuteman III missile squadron in the Air Force. Six months later, the 810th Strategic Aerospace Division was deactivated and the 91st SMW became the senior tenant unit on base. At this point, the 91st SMW was then assigned to the 4th Strategic Missile Division, Francis E. Warren AFB, Wyoming, and the 5th BMW became part of the 47th Air Division (AD), Fairchild AFB, Washington. In December 1971, the 91st SMW became the first fully-operational Minuteman III Wing in the Air Force. The missile wing was realigned under the 47th AD in January 1973.

In January 1975, the 57th AD was activated at MAFB, replacing the 47th AD at both MAFB and Grand Forks AFB. This move localized command and insured that assigned units would be capable of conducting aerial refuel-
(CL5065A/1)

ing, missile warfare and strategic reconnaissance according to the emergency war order. The 57th AD was later reorganized and augmented to fulfill Strategic Projection Force (SPF) responsibilities. On May 1, 1982, the 44th SMW and the 28th BMW at Ellsworth AFB, South Dakota were realigned to become members of the 57th AD. In addition, on May 1, 1975, Grand Forks AFB was assigned to the 4th AD at F.E. Warren AFB, Wyoming. The 55th Reconnaissance Wing, Offutt AFB, Nebraska, 28th BMW, Ellsworth AFB and 5th BMW at MAFB combine to make up the SPF.

MAFB is presently the home of the 57th AD, 91st SMW, 5th BMW, 91st Combat Support Group, USAF Regional Hospital, 5th Fighter Interceptor Squadron, 2150th Communications Squadron and several other tenant units.

D.2 Hazardous Materials Handling

The major industrial operations at MAFB and its subinstallations relate to the maintenance of aircraft, missiles, ground vehicles and support facilities for the 91st SMW, 5th BMW and the 91st Combat Support Group. Operations include the following: engine repairs and overhauls; electrical, hydraulic and fuel system repairs; painting; metal plating and finishing; missile system maintenance; aircraft maintenance; fuel supply and handling; and additional activities.

The main types of waste generated at MAFB are fuels, oils, solvents, paints and paint strippers, metal plating and treatment solutions and minor amounts of explosives and pesticides. Waste fuel, including JP-4 fuel, oil, solvents, engine oil, PD680 and acetone are produced primarily from periodic maintenance and engine repair. Since the establishment of the base, the general trend in waste disposal has transposed from unsegregated disposal in base landfills to extensive waste segregation disposal in base landfills and contract disposal.

D.3 Potential Sources of Environmental Contamination

Three major sites of potential environmental contamination have been identified at MAFB in the Phase I - Records Search Report. These include: 1) the Sanitary Landfill Area, 2) the Firefighting Training Area, and 3) the Explosive Ordnance Disposal Area. A brief description of each of these areas can be found in Part B of this chapter (B.1, B.2 and B.3, respectively).

E. Identification of Pollutants Sampled

Three different types of analytical methods were used to evaluate the environmental quality of the materials sampled. Analytical methods included: 1) prescreening subsurface soil and surface sediment samples with an Organic Vapor Analyzer (OVA); 2) field analysis for all ground water and surface water samples for pH, conductivity and temperature; and 3) laboratory chemical analyses for subsurface soil, surface sediment and water samples.

A total of six subsurface soil and six surface sediment samples were collected in the FTA and in the drainage ditch leading away from the FTA. In addition, five subsurface soil samples were collected in the EOD. As outlined in the TOP, only four subsurface soil and four surface sediment samples from the FTA and two subsurface soil samples from the EOD could be submitted to the laboratory for chemical analyses. Therefore, an OVA screening technique was used in conjunction with physical characteristics (color and odor) to select samples with the greatest potential for contamination to be sent for laboratory analyses. This OVA screening method is described in detail in Section III of this report.

Laboratory analyses was the second analytical method used to evaluate environmental quality of samples. All samples collected were placed in laboratory-prepared containers, placed on ice and shipped by overnight courier to Princeton Testing Laboratories, Princeton, New Jersey. As an external QA/QC check, duplicates of samples sent to Princeton Testing (CL5065A/1)

Laboratories were sent to USAFOEHL for analyses. Ground water and surface water samples from the SLA were analyzed for aromatic and halogenated volatile organic compounds, total petroleum hydrocarbons, priority pollutant metals, extractable priority pollutant organics, total dissolved solids and common anions. Ground water, subsurface soil and surface sediment samples from the FTA were analyzed for total petroleum hydrocarbons, aromatic and halogenated volatile organic compounds and lead. Subsurface soil samples from the EOD were analyzed for total petroleum hydrocarbons and priority pollutant metals. The COE well water sample was analyzed for total petroleum hydrocarbons, aromatic and halogenated volatile organic compounds, priority pollutant metals, total dissolved solids and common anions. As a third analytical evaluation method, all water samples were field tested for pH, conductivity and temperature.

F. Participants in the Field Investigation

Personnel involved in the field investigation effort consisted of HART personnel, Air Force technical monitors and observers and subcontractors.

F.1 HART Personnel

James Mack - Contract Program Manager

Robert Goldman - Project Manager

Vanessa DeVillez - Hydrogeologist/Field Team Leader

James Volz - Geologist

F.2 Air Force Personnel

Captain Patrick N. Johnson - USAFOEHL Program Monitor

Captain David DeMay - Base Point of Contact

Lt. Col. John Pontier - MAJCOM Monitor

Mr. John L. Boucher - Base Environmental Engineer

Sergeant Joseph Farrell - Base Point of Contact

F.3 Subcontractors

Subcontractors who participated in the field investigation portion of this contract include:

Drilling and Well Installation: Twin City Testing, Inc.
3100 E. Broadway
Box 1114
Bismarck, ND 58502

Surveyor: Nesdahl Surveying & Engineering
P.O. Box 1014
Minot, ND 58702

Chemical Laboratory: Princeton Testing Laboratory
Princeton Service Center
U.S. Route One
Princeton, NJ 08540

Geotechnical Laboratory: J & L Testing Company
113 Kimber Drive
Bridgeville, PA 15017

II. ENVIRONMENTAL SETTING

A. Physical Geography

MAFB is located in the Drift Prairie Plain District of the Central Lowlands Physiographic Province (Figure II-1). The Drift Prairie Plain is a northeast-sloping, gently to moderately undulating plain that extends from the northeast edge of the Missouri Coteau District northwest into Canada. MAFB is located approximately 15 miles northeast of the Missouri Escarpment which forms the northeastern margin of the Missouri Coteau. The "escarpment" gently slopes from the highlands of the Missouri Coteau to the lowlands of the Drift Prairie Plain.

MAFB is located within the Souris River Drainage System. The Souris and Des Lacs Rivers are the only perennial streams in Ward and Renville Counties (Pettyjohn and Hutchinson, 1971). Intermittent streams in the vicinity of MAFB include Little Deep Creek, Egg Creek, Livingston Creek and an additional unnamed creek that runs through the western-most portion of the base and south until it intersects with Livingston Creek.

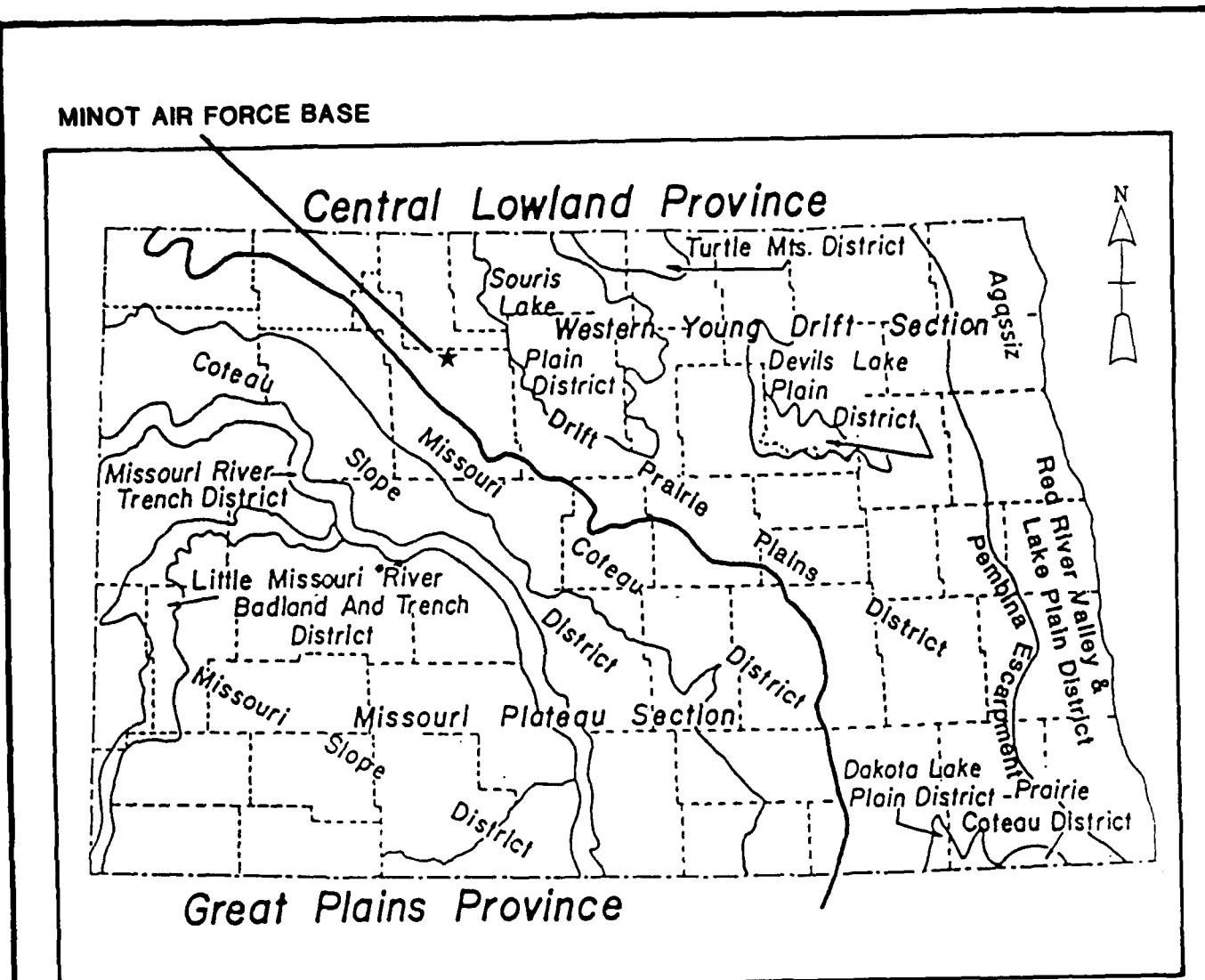
Climate in the Drift Prairie Plain is subhumid to semi-arid. The average yearly precipitation is 15.5 inches and exhibits great variation. Average temperatures in January and July are 6.6°F and 68.8°F, respectively.

Maximum relief surrounding MAFB is less than 50 ft and the average elevation is approximately 1,630 feet above mean sea level.

B. Regional Geology And Hydrogeology

B.1 Regional Geologic Setting

The geology underlying MAFB and the surrounding area can be subdivided into two distinct zones: Quaternary glacial and alluvial sediments and bedrock.



SOURCE: Hansen and Kume, 1970

FIGURE II-1
PHYSIOGRAPHIC PROVINCES
OF NORTH DAKOTA

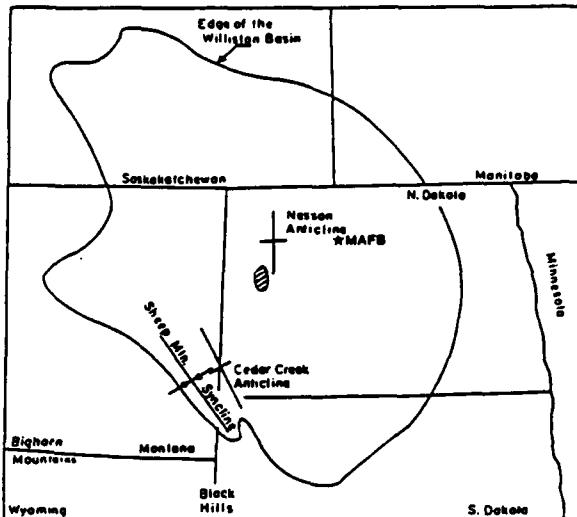
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B.1.a Bedrock Geology. The western two-thirds of North Dakota contains rocks of the Williston Basin (Figure II-2). MAFB is located on the east flank of the basin. The regional dip of bedrock units in the Minot area is less than one degree (Bluemle, 1977). However, the bedrock surface in the area is eroded to slope about 10 ft per mile to the northeast (Lemke, 1960).

Regionally, bedrock occurs buried beneath Quaternary deposits at depths ranging from 0 to 600 ft (Pettyjohn and Hutchinson, 1971). Rocks younger than Upper Paleocene were removed by erosion prior to Pleistocene Glaciation; therefore, the youngest bedrock unit encountered is the Paleocene Fort Union Group. Pettyjohn and Hutchinson (1971) drilled numerous test borings in the area surrounding MAFB. The logs for these test borings can be found in Appendix D. These logs indicate that the bedrock surface below MAFB exists at depths ranging from approximately 150 to 220 ft.

The Fort Union Group is composed of the following four formations in ascending order: Ludlow, Cannonball, Tongue River and Sentinel Butte. The Ludlow Formation is a continental deposit and consists of beds of silty sand and clay and contains a few lignite beds. The Cannonball Formation is a marine deposit that consists of dark-gray sand, clay and a few thin layers of nodular, fossiliferous limestone. The Tongue River Formation consists of continental deposits of clay, silt, sandstone and numerous lignite beds. The Sentinel Butte Formation is very similar to the Tongue River Formation and normally cannot be distinguished from the Tongue River in the subsurface. The total thickness of the Fort Union Group in J.H. Kline Well 1 (Pettyjohn and Hutchinson, 1971) is 615 ft (The J.H. Kline Well 1 is an oil well located approximately 15 miles west of MAFB).

Beneath the Fort Union Group is the Upper Cretaceous Hell Creek Formation which consists of fine to medium-grained sandstone, siltstone and shale. The thickness of the Hell Creek Formation in the Minot area is about 205 ft (Pettyjohn and Hutchinson, 1971).



SOURCE: BLUEMLE, 1960.

Era	System	Series	Geologic unit	Physical character	Thickness (feet)	Water-yielding characteristics
Cenozoic	Tertiary	Paleocene	Fort Union Group	Sandstone, silt, shale, and lignite.	0-700	Generally of low permeability. Yields small quantities of water, generally adequate for domestic and stock use. Water may be saline and contain dissolved gas.
Mesozoic	Cretaceous	Upper Cretaceous	Hell Creek Formation	Mudstone, sandy shale, sandstone, and lignite.	200±	Relatively impermeable. May yield very small quantities of water in the area.
			Fox Hills Formation	Sandstone and shale.	235±	Permeable. Yield unknown.
			Pierre Formation	Consolidated bluish-gray to dark-gray marine shale, sandy in places, fossiliferous, contains many concretions in places.	1,200±	Relatively impermeable. May yield very small quantities of water from sand lenses and fractures common in the upper part.
		Lower Cretaceous	Colorado Group	Consolidated dark-gray shale, dense, calcareous, and bentonitic; also limestone, which may include alternating layers of shale and sandstone.	1,060±	Relatively impermeable. Not known to yield water in the area. Sandstone may yield limited supplies.
Lower Cretaceous		Dakota Group	Sandstone, fine to coarse grained; consolidated, calcareous, and very bentonitic shale.	600±	Permeable. Yields large quantities of saline water from depths of 2,500± feet.	

SOURCE: Pettyjohn and Hutchinson, 1971

FIGURE II-2
BEDROCK FORMATIONS OF
THE WILLISTON BASIN
IN THE MINOT AREA

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Underlying the Hell Creek Formation is the Upper Cretaceous Fox Hills Formation. This unit consists of intercalated sandstone and shale. The thickness of the Fox Hills Formation in J.H. Kline Well 1 is about 235 ft.

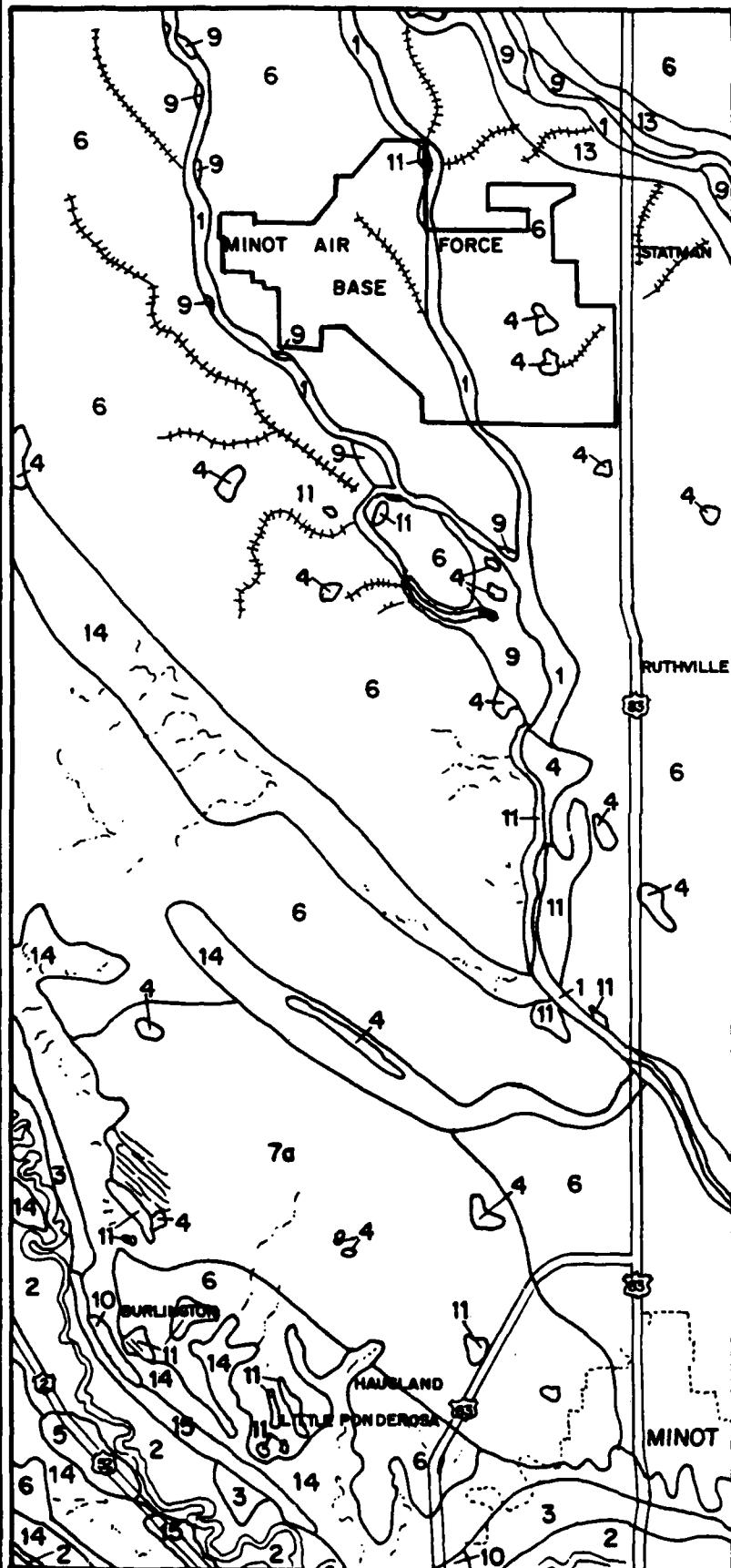
Beneath the Fox Hills Formation is the Upper Cretaceous Pierre Formation and Colorado Group. These two units each exceed 1,000 ft in thickness and are largely composed of shale with minor occurrences of sandstone and limestone (Pettyjohn and Hutchinson, 1971).

Beneath the Colorado Group is the Lower Cretaceous Dakota Group, which consists of sandstone, siltstone and shale. The total thickness of the Dakota Group in J. H. Kline Well 1 is 306 ft.

Underlying these Cretaceous sediments are several thousand feet of limestone, sandstone, shale, dolomite and evaporites.

B.1.b Quaternary Glacial and Alluvial Geology. Sediments deposited during the Pleistocene Glaciation rest unconformably upon the Paleocene Fort Union Group bedrock. In North Dakota, these Pleistocene sediments comprise the Coleharbor Group (Bluemle, 1971). Sediments include glacial till, fluvial sand and gravel and lacustrine silt and clay deposits (Kehew, 1983). Glacial till, the most widespread of these deposits, consists of a heterogeneous mixture of clay, silt, sand and larger fragments and occurs as an unstratified ground moraine deposit (Pettyjohn and Hutchinson, 1971). Scattered throughout the ground moraine are buried deposits of sand and gravel (Pettyjohn and Hutchinson, 1971).

Surface glacial sediments throughout most of the Minot area were derived from the Late Wisconsin Glaciation, the final glacial advance and retreat in North Dakota, between 25,000 and 12,000 years ago (Clayton and others, 1980). These surface deposits of the Coleharbor Group have been divided into 10 map units. The occurrence of these units in the Minot area is shown on Figure II-3; a brief description of each unit is found in the legend.



LEGEND

1	Oahe Formation	Dark, obscurely bedded clay and silt, may overlie Sand and Gravel of Coleharbor Group
2	Oahe Formation	Dark, obscurely bedded clay and silt; occasionally overlying cross-bedded sand and gravel. Wood, shells and bone fragments present.
3	Oahe Formation	Dark, obscurely bedded sandy to silty clay.
4	Oahe Formation	Dark, obscurely bedded clay and silt.
5	Oahe Formation, Coleharbor Group, Fort Union Group undivided	Bedded sand, silt, clay and lignite and/or non-bedded sand, silt, clay and gravel (till). Bedding may be disturbed or distorted. Exposures may be out of place stratigraphically.
6	Coleharbor Group	Non-bedded and poorly sorted sand, silt, clay, pebbles, cobbles, and boulders (till).
7	Coleharbor Group	Same as unit 6.
7a	Coleharbor Group	Same as unit 6.
8	Coleharbor Group	Same as unit 6.
9	Coleharbor Group	Bedded sand and gravel.
10	Coleharbor Group	Plane-bedded gravel and sand; mostly poorly sorted gravel containing large boulders.
11	Coleharbor Group	Cross-bedded sand and gravel; bedding disrupted and contorted.
12	Coleharbor Group	Laminated clay and silt.
13	Coleharbor Group	Same as unit 6.
14	Coleharbor Group	Non-bedded and poorly sorted sand silt, clay, pebbles, cobbles, and boulders; contains patches of bedded sand and silty sand.
15	Fort Union Group	Alternating beds of sand, silt, clay and lignite.

SYMBOLS

- IRREGULAR, COLLAPSED CHANNEL ERODED BY GLACIAL MELTWATER.
- - - BOTTOMS OF SMALL UNCOLLAPSED RIVER CHANNELS.
- LINEAR/CURVILINEAR LINEATION IN GLACIAL SEDIMENT.

0 1 2 3
Scale (Miles)

FIGURE II-3

SURFACE DEPOSITS
OF THE MINOT AREA

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Sediments deposited during Holocene time, the time period immediately following glaciation and continuing to the present, are assigned to the Oahe Formation (Kehew, 1983). The sediments of the Oahe Formation are predominantly alluvial, deposited from streams during deglaciation (Kehew, 1983). Two additional types of sediment assigned to the Oahe Formation are eolian sediments accumulating in shallow depressions and landslide deposited sediment. The Oahe Formation has been divided into five map units. The occurrence of these map units in the Minot area is shown on Figure II-3; a brief description of each of the units is found in the legend.

B.2 Regional Hydrogeologic Setting

The area surrounding MAFB can be subdivided into three major ground water areas: (1) the Missouri Coteau Recharge Area; (2) the Des Lacs Artesian Discharge Area; and (3) the Central Recharge Area (Pettyjohn and Hutchinson, 1971; Figure II-4). The Missouri Coteau is an area of about 730 square miles southwest of MAFB. It is characterized by thousands of small, undrained depressions in the glacial till that accumulate large quantities of surface water. Part of this water seeps downward through the till and recharges gravel, sand and lignite aquifers and then flows laterally to adjacent areas of discharge (Pettyjohn and Hutchinson, 1971).

The Des Lacs Artesian Discharge Area is a belt of approximately 870 square miles in area and parallel to the northeastern edge of the Missouri Coteau and the Des Lacs River in which bedrock wells flow or once flowed at the surface (Pettyjohn and Hutchinson, 1971). The area ranges from 6 to 9 miles in width along the Des Lacs River and widens to nearly 20 miles along the Souris River southeast of MAFB.

The Central Recharge Area is a 1,330-square mile, nearly flat expanse of ground moraine that slopes gently to the northeast and contains thousands of small, poorly drained prairie potholes (Pettyjohn and Hutchinson, 1971). MAFB is located within the Central Recharge Area. Throughout (CL5064A)

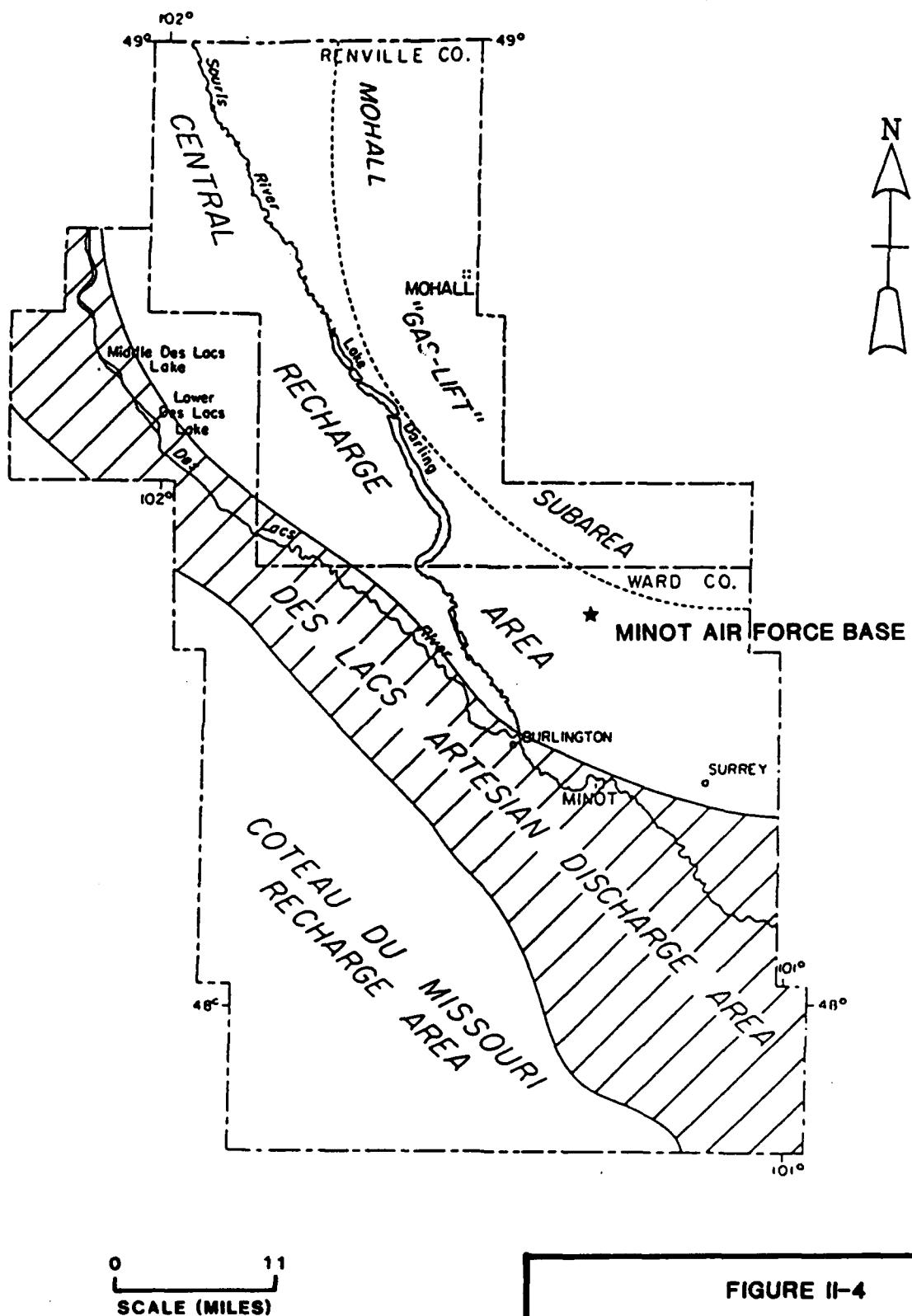


FIGURE II-4
MAJOR GROUNDWATER
RECHARGE AND DISCHARGE AREAS

SOURCE: Pettyjohn and Hutchinson, 1971

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most of the Central Recharge Area, wells tapping the glacial drift have higher water levels than nearby wells in the underlying bedrock; and, where two closely spaced observation wells are constructed in the glacial drift, the shallow observation well has the higher water level (Pettyjohn and Hutchinson, 1971). Lower water levels in progressively deeper wells suggests the vertical component of ground water movement is downward and that ground water is recharging deeper aquifers throughout the area.

B.2.a Bedrock Aquifers. Several thousand feet of limestone, sandstone, shale, dolomite and evaporite lie beneath the Cretaceous Dakota Group. However, most of the water in Pre-Cretaceous strata is brine, with dissolved solids commonly exceeding 57,000 ppm. No water wells in either Renville or Ward Counties are known to penetrate these strata (Pettyjohn and Hutchinson, 1971). The Lower Cretaceous Dakota Group can yield very large quantities of water; however, the water is saline and unsuitable for domestic or agricultural uses (Pettyjohn and Hutchinson, 1971). The Upper Cretaceous Colorado Group and Pierre Formation have very limited water yielding capabilities (Pettyjohn and Hutchinson, 1971). In summary, no strata below the Upper Cretaceous Fox Hills Formation are considered useful water sources and therefore warrant no further discussion in this report.

No wells in Renville or Ward Counties are definitely known to produce from the Fox Hills Formation; however, many wells produce water from this formation in southwestern North Dakota (Pettyjohn and Hutchinson, 1971). The water from this formation is slightly to highly saline, generally soft and could be used for domestic and municipal supplies (Pettyjohn and Hutchinson, 1971).

The Hell Creek Formation in the Minot area is not known to yield large quantities of water; however, several water-bearing zones may be screened and a large yield could be obtained by a single well (Pettyjohn and Hutchinson, 1971). The water may be saline and it contains a high percentage of iron, sodium and sulfate.

(CL5064A)

According to Pettyjohn and Hutchinson (1971), the lignite and fine-grained sandstone layers in the Fort Union Group are a source of water for wells and springs. Although water from these aquifers is used for drinking, it generally contains more chloride than is recommended by the U.S. Public Health Service for human consumption. The water is used for watering livestock, but because of its salinity, it is unsuitable for irrigation.

B.2.b Quaternary Glacial and Alluvial Aquifers. Water wells located in glacial sediments produce from buried sand and gravel deposits. These types of deposits are pervasive in the glacial sediments; however, it is only when these deposits are laterally and vertically extensive that they become important sources of water. With the exception of deposits in modern and ancient stream valleys, there are no widespread buried deposits of water-bearing sand and gravel in Renville and Ward Counties (Pettyjohn and Hutchinson, 1971).

There are several water-bearing sand and gravel deposits in the Souris River Valley, in and around Minot, that are presently being used as water supplies or have the potential to become water supplies (Pettyjohn and Hutchinson, 1971). Some of these are the Burlington Aquifer, the Minot Aquifer, the North Hill Aquifer and the Northwest Buried Channel Aquifer (Figure II-5). However, none of these aquifers are within a five mile radius of MAFB and warrant no further discussion in this report as they do not represent potential receptors of contamination.

Pettyjohn and Hills (1965) completed a study entitled "Geohydrology of the Souris River Valley in the Vicinity of Minot, North Dakota." Comeskey and Reiten (1982) completed a study entitled "Ground Water Resources of the Surry Area, Ward County, North Dakota." Both of these studies involved sampling and chemical analyses of ground water samples (Table II-1). The ground water samples from the Pettyjohn and Hills (1965) study were obtained from the buried channel aquifers located in the vicinity of the Souris River Valley near Minot. These aquifers are shown in Figure II-5. The ground water samples from the Comeskey and Reiten (CL5064A)

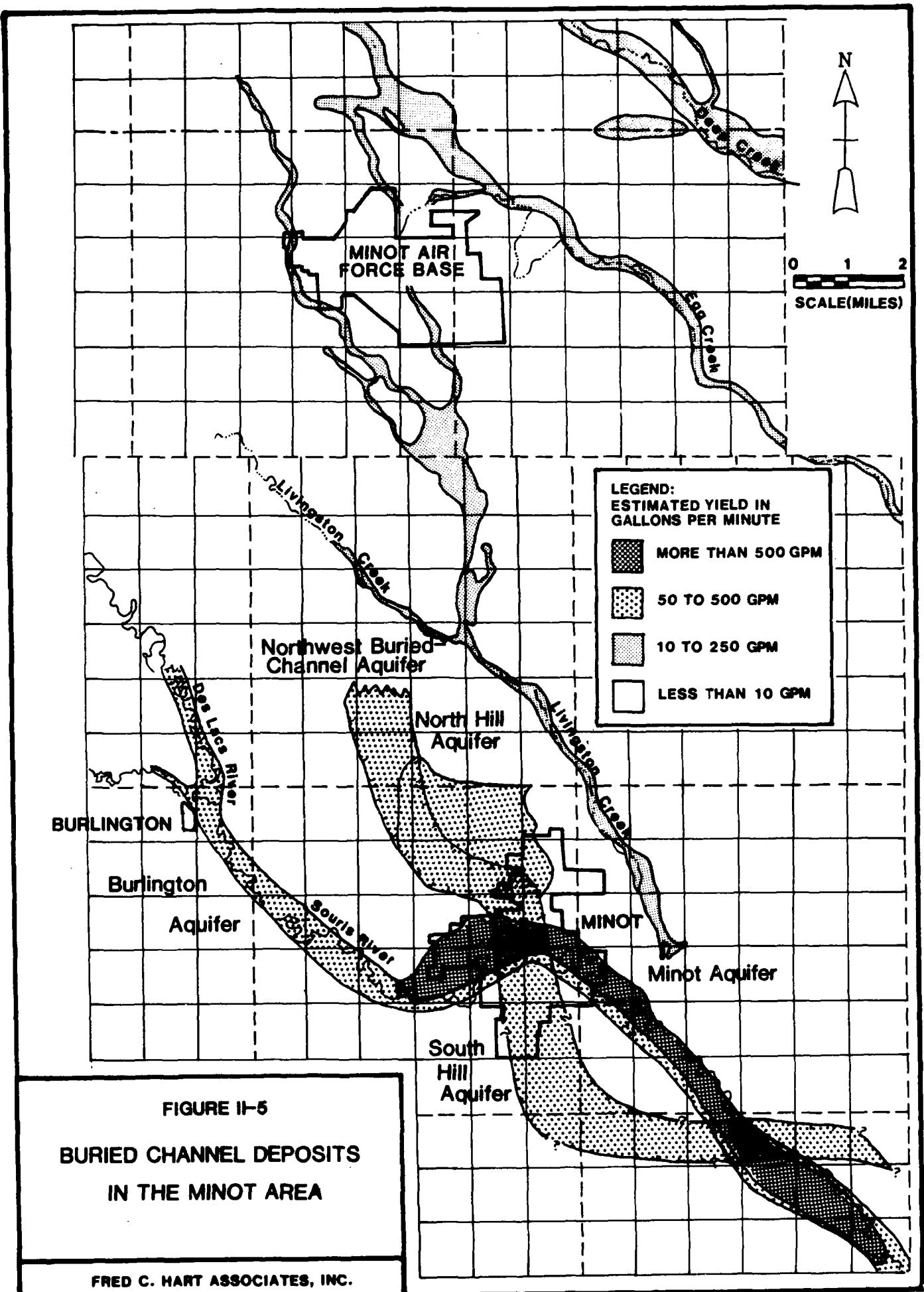


TABLE II-1

CHEMICAL ANALYSES OF GROUND WATER
IN THE VICINITY OF MINOT, NORTH DAKOTA

<u>Sample No.</u>	<u>Well Location¹</u>	<u>Source²</u>	<u>Depth (ft)</u>	<u>Parameter (mg/l)</u>			<u>TDS</u>
				<u>Sulfate</u>	<u>Chloride</u>	<u>Nitrate</u>	
1	154-82-4aad	TH2214	233	195	17	1.5	800
2	154-82-4aba	TH2213	120	165	14	3.0	679
3	155-82-19dbd	TH2216	107	133	79	3.0	904
4	155-82-29bcb	TH2215	105	145	140	2.0	936
5	155-83-14cda	City 10	139	110	146	1.0	994
6	155-83-14dbal	TH2233	170	381	219	1.0	1,570
7	155-83-14dca	City 9	148	181	338	4.5	1,410
8	155-83-14ddd2	City 5	147	72	232	0.0	980
9	155-83-14ddd3	City 6	139	225	137	1.5	1,100
10	155-83-21daa2	City 18	99	35	92	0.0	882
11	155-83-22abc	City 15	115	96	24	0.0	558
12	155-83-22acc1	City 14	105	44	97	1.0	982
13	155-83-22ada2	City 12	120	165	29	1.0	788
14	155-83-22adc	City 13	115	74	102	0.0	885
15	155-83-22bcd1	City 17	87	83	49	1.0	719
16	155-83-22bdc	City 16	111	26	112	2.0	884
17	155-83-23baa	City 7	125	129	32	1.0	648
18	155-83-23bab1	City 8	132	96	81	1.0	896
19	155-83-23bab2	TH2227	118	130	40	0.0	663
20	155-83-23bab3	TH2227A	21	179	33	0.0	723
21	155-83-23bab1	TH2222	100	179	36	0.0	789
22	155-83-23bba3	TH2225	104	172	38	20.0	670
23	155-83-23bba4	TH2225A	21	190	29	2.0	693
24	155-83-23bba5	TH2226	117	186	43	2.0	743
25	155-83-23bba5	TH2226A	21	92	30	30.0	666
26	155-83-23bba7	TH2241	102	115	23	4.8	694
27	155-83-23bba8	TH2241A	18	153	25	2.0	676
28	155-83-23bbb3	TH2224	101	130	23	0.5	593
29	155-83-23bbb4	TH2228	110	74	55	0.0	622
30	155-83-23bbb5	TH2228A	21	86	21	1.0	529
31	155-83-23bbb7	TH2232	21	90	33	2.5	644
32	155-83-23bbc1	TH2229	100	81	20	3.0	545
33	155-83-23bbc2	TH2229A	21	143	34	2.0	603
34	155-83-23bbc3	TH2230	83	23	21	1.0	551
35	155-83-23bbd	City 11	130	128	29	1.0	722
36	155-81-11ccc	NDSWC9559	36	160	8.4	1.0	625
37	155-81-11ccc	NDSWC9559	36	160	3.8	0.6	689
38	155-81-11ccd	NDSWC9560	57	390	19	0.1	1,100
39	155-81-11ccd	NDSWC9560	57	530	21	0.6	1,340
40	155-81-11cdd	NDSWC11091	53	470	27	1.4	1,120
41	155-81-13aaa	NDSWC11080	73	100	6.2	1.0	404

Table continued on next page.

(CL5022B/2)

TABLE II-1 (CONTINUED)

CHEMICAL ANALYSES OF GROUND WATER
IN THE VICINITY OF MINOT, NORTH DAKOTA

<u>Sample No.</u>	<u>Well Location¹</u>	<u>Source²</u>	<u>Depth (ft)</u>	<u>Parameter (mg/l)</u>			<u>TDS</u>
42	155-81-13aaa	NDSWC11094	68	200	11	1.0	542
43	155-81-13aba	NDSWC11095	51	190	9.9	1.0	447
44	155-81-14baa	NDSWC11112	39	25	5.1	1.0	337
45	155-81-14bbb	NDSWC11071	33	420	20	0.6	980
46	156-81-36ccc	NDSWC11105	42	400	11	1.0	853
47	155-80-18aaba	NDSWC11769	43	710	28	1.0	1,390
48	155-80-18abac	NDSWC11764	63	880	44	8.8	1,820
49	155-80-18abca	NDSWC11762	48	400	41	4.6	1,090
50	155-80-18abcb	NDSWC11759	71	190	27	1.6	634
51	155-80-18abcc	NDSWC11760	48	130	25	4.1	620
<u>Average</u>			85	193	54.5	2.5	818
<u>Range</u>			18-233	23-880	3.8-338	0-30.0	337-1,820
<u>Median</u>			99	145	29	1.0	722

Legend

- 1- "Well Location" refers to the township and range coordinates of the particular well; none of these wells are located within a mile of the sites investigated at MAFB
- 2- TH - USGS Test Hole.
NDSWC - North Dakota State Water Commission.

Sources

Sample No.'s 1 through 36:

Pettyjohn and Hills, 1965, "Geohydrology of the Souris River Valley in the Vicinity of Minot, North Dakota."

Sample No.'s 36 through 51:

Comeskey and Reiten, 1982, "Ground Water Resources of the Surry Area, Ward County, North Dakota."

(CL5022B/2)

(1982) study were obtained from an unnamed glacial aquifer northeast of Surry in Township 155 North, Range 81 West, Sections 9 through 14 and Township 155 North, Range 80 West, Sections 7, 8 and 18. This aquifer ranges from 0 to 50 ft thick.

Several ice marginal channel deposits around Minot contain sufficient thicknesses of saturated sand and gravel to be productive aquifers (Pettyjohn and Hutchinson, 1971). These deposits are depicted in Figure II-5 as aquifers with estimated yields of 10 to 250 gallons per minute (gpm). These deposits are near surface and generally less than 30 feet below grade. They are commonly a quarter-mile to a half-mile in width and vary in length, although they can be as long as 40 miles. The sediment in these deposits ranges in size from clay to boulders, but sand and fine to medium gravel predominate. These deposits are normally found in immediate proximity to the intermittent streams that drain the area, which are remnants of larger, ice marginal streams that once flowed the same course. Several stock, domestic and municipal wells obtain water from these types of deposits (Pettyjohn and Hutchinson, 1971).

C. Site Geology And Hydrogeology

According to Kehew (1983), the entire area surrounding MAFB is part of a large, laterally and vertically continuous ground moraine plain. Ground moraine typically consists of an unsorted, unstratified mixture of sediments, generally referred to as till. The sediments include clay, silt, sand, gravel and cobble sized clasts; however, clay and silt are the most common sediment type and comprise the largest percentage of the sediment volume. The normal sequence encountered in the till of the Minot area consists of an upper and lower zone (Bluemle, 1986). The distinction between the upper and lower zones of the till is based on variations in color, due to the effects of oxidation. The upper oxidized zone is light brown, as opposed to the lower, gray, unoxidized zone. The depth at which the lower zone is first encountered is a function of the depletion rate of dissolved oxygen as percolating surface water migrates through the sediments. The boundary between the upper and lower zones of the till in the (CL5064A)

Minot area can be encountered at depths up to 30 feet below the surface, although normally it is encountered at more shallow depths (Bluemle, 1986).

The concepts typically used to evaluate and describe the hydrogeology of an area are difficult to apply in this study area due to the nature of the geologic units that underlie the installation. A water table is defined as either the boundary between the unsaturated and saturated zones or the depth at which the interstitial pore space is filled with water under atmospheric pressure (Freeze and Cherry, 1979). The location of the water table surface is revealed by the level at which water stands in a shallow well open along its length and penetrating the surficial deposits just deeply enough to encounter standing water in the bottom (Freeze and Cherry, 1979). However, locating the water table by this method in the glacial till underlying MAFB would be unsuccessful due to the impermeable nature of a till. Despite its degree of saturation, till generally yields little or no water to wells (Pettyjohn and Hutchinson, 1971).

As discussed in Section II-B.2, MAFB is located within the Central Recharge Area. The Souris River Valley, located approximately 15 miles south-southwest of MAFB, is the only zone of ground water discharge in this area; however, because of the low permeability of the till, the quantity of ground water discharged to the Souris River ranges from small to negligible, depending upon the time of year (Pettyjohn and Hutchinson, 1971). Therefore, the vertical movement of ground water is likely the dominant component of flow in the vicinity of MAFB.

(CL5064A)

III. FIELD PROGRAM

A. Introduction

This chapter provides a detailed summary of field investigations at MAFB between October 6, 1986 and November 2, 1986. These investigations involved the following: a test boring program; installation of ground water monitoring wells; ground water, surface water, sediment and soil sampling and analyses; water level measurements; and surveying.

B. Test Boring Program

A test boring program was conducted at MAFB to assess the local geology, gain information regarding grain size distribution and permeability of the individual geologic units and to assess the presence and distribution of potential contamination. (Appendix D contains the test boring logs). It is noted that the test boring program (drilling locations and methods) varied slightly at each of the three areas under investigation due to variations in local conditions and the scope of work within each area.

B.1 The Sanitary Landfill Area (SLA)

The test boring program at the SLA included the drilling of eight test borings. The locations of these test borings are shown in Figure III-1. Some changes were made from the originally proposed boring locations outlined in the Technical Operations Plan. However, all changes made were in accordance with USEPA recommendations and confirmed by USAFOEHL personnel.

Test borings DW-1 and DW-4 were drilled to a depth of 100 feet. These borings served to: (1) characterize the geology and (2) determine the depth at which shallow and deep monitoring wells should be installed at these sites. Wells were never installed in these 100-foot borings. The borings were tremie-grouted to the surface using a bentonite-cement mixture; then, new boreholes were drilled a short distance away from the (CL5074A/1)

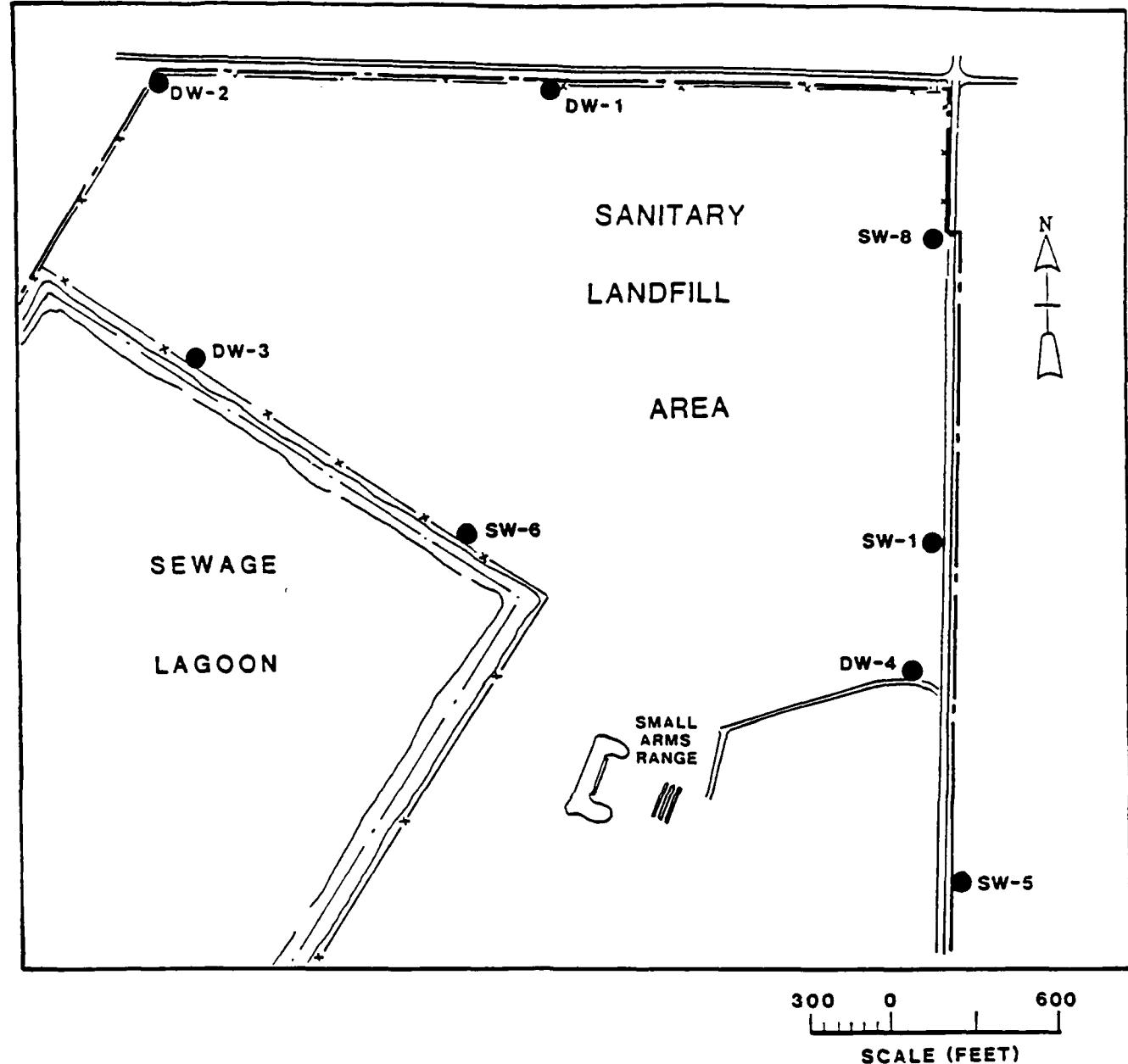


FIGURE III-1

LOCATIONS OF TEST BORINGS
IN THE SANITARY LANDFILL AREA
MINOT AIR FORCE BASE

FRED C. HART ASSOCIATES, INC.

test borehole (five feet or less) to the appropriate depths. The remaining six test boreholes were drilled to characterize the geology down to the first water-bearing zone, at which depth a well was installed. Depths of test borings and monitoring wells are summarized in Table III-1.

B.2 The Firefighting Training Area (FTA)

The test boring program at the FTA included the drilling of four test borings. The locations of these test borings are shown in Figure III-2. The locations of these test borings were confirmed by USAFOEHL personnel. Test boring TB-1 was drilled to a depth of 30 feet to obtain soil samples for chemical analysis. The remaining three test borings were used to characterize the geology down to the shallow water-bearing zone (less than 30 feet) and to install monitoring wells. Test borehole SW-7 did not penetrate a water-bearing zone and, therefore, no well was installed. The depths of the test borings drilled at the FTA are summarized in Table III-1.

B.3 The Explosive Ordnance Disposal Area (EOD)

The test boring program in the EOD consisted of one test boring. The location of this test boring is shown in Figure III-3 and was confirmed by USAFOEHL personnel. This boring was drilled to a depth of 20 feet to obtain soil samples for chemical analyses. No well was installed in this test boring.

B.4 Drilling Methodology

All of the test borings at MAFB were drilled by Twin City Testing, Inc. of Bismarck, North Dakota, under close supervision and direction of a HART hydrogeologist. All but three of the test borings drilled used the hollow-stem, continuous-flight auger technique. This technique allows for continuous advancement of the borehole while providing access for sampling and shallow well installation. The mobile drill rig was equipped with a (CL5074A/1)

TABLE III-1

SANITARY LANDFILL AREA (SLA) AND FIREFIGHTING
TRAINING AREA (FTA) BORINGS DATA

<u>BORING NUMBER</u>	<u>LOCATION</u>	<u>BORING DEPTH (FT)</u>	<u>SAMPLING*</u>
SW-1	SLA	16.0	YES
SW-2	SLA	20.5	NO
SW-3	SLA	25.5	YES
SW-4	SLA	16.5	NO
SW-5	SLA	18.0	YES
SW-6	SLA	50.0	YES
SW-6	SLA	20.0	NO
SW-7	FTA	27.0	YES
SW-8	FTA	30.0	YES
SW-9	FTA	25.0	YES
DW-1	SLA	97.0	YES
DW-1	SLA	50.0	NO
DW-2	SLA	43.5	YES
DW-3	SLA	44.0	YES
DW-4	SLA	100.0	YES
DW-4	SLA	45.0	NO
TB-1	FTA	30.0	YES

* Logs for SLA and FTA test borings (borings which involved sampling) can be found in Appendix D. Borings which involved no sampling were drilled adjacent to test borings for the purpose of monitoring well installation.

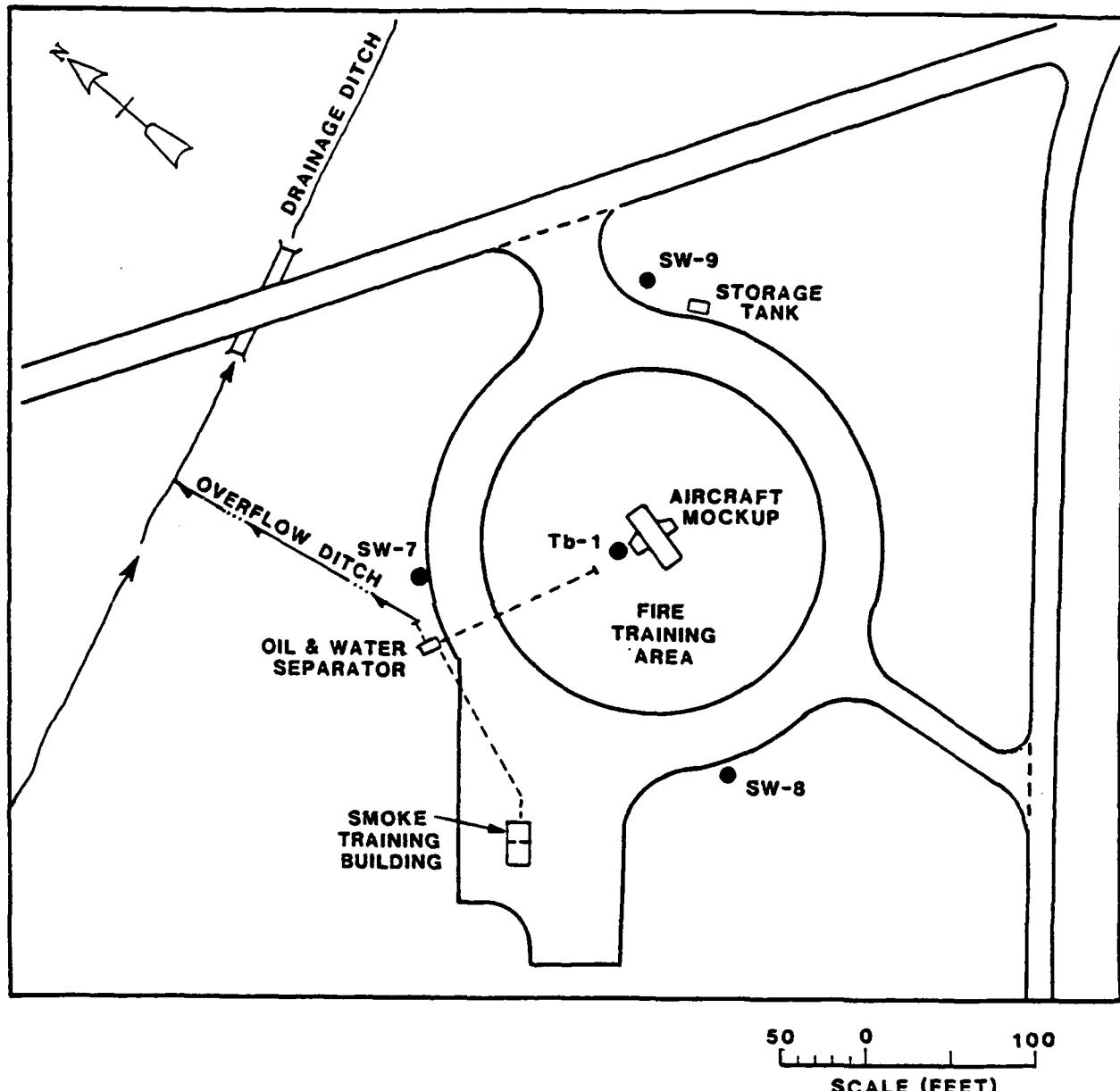


FIGURE III-2

LOCATION OF TEST BORINGS
IN THE FIREFIGHTING
TRAINING AREA
MINOT AIR FORCE BASE

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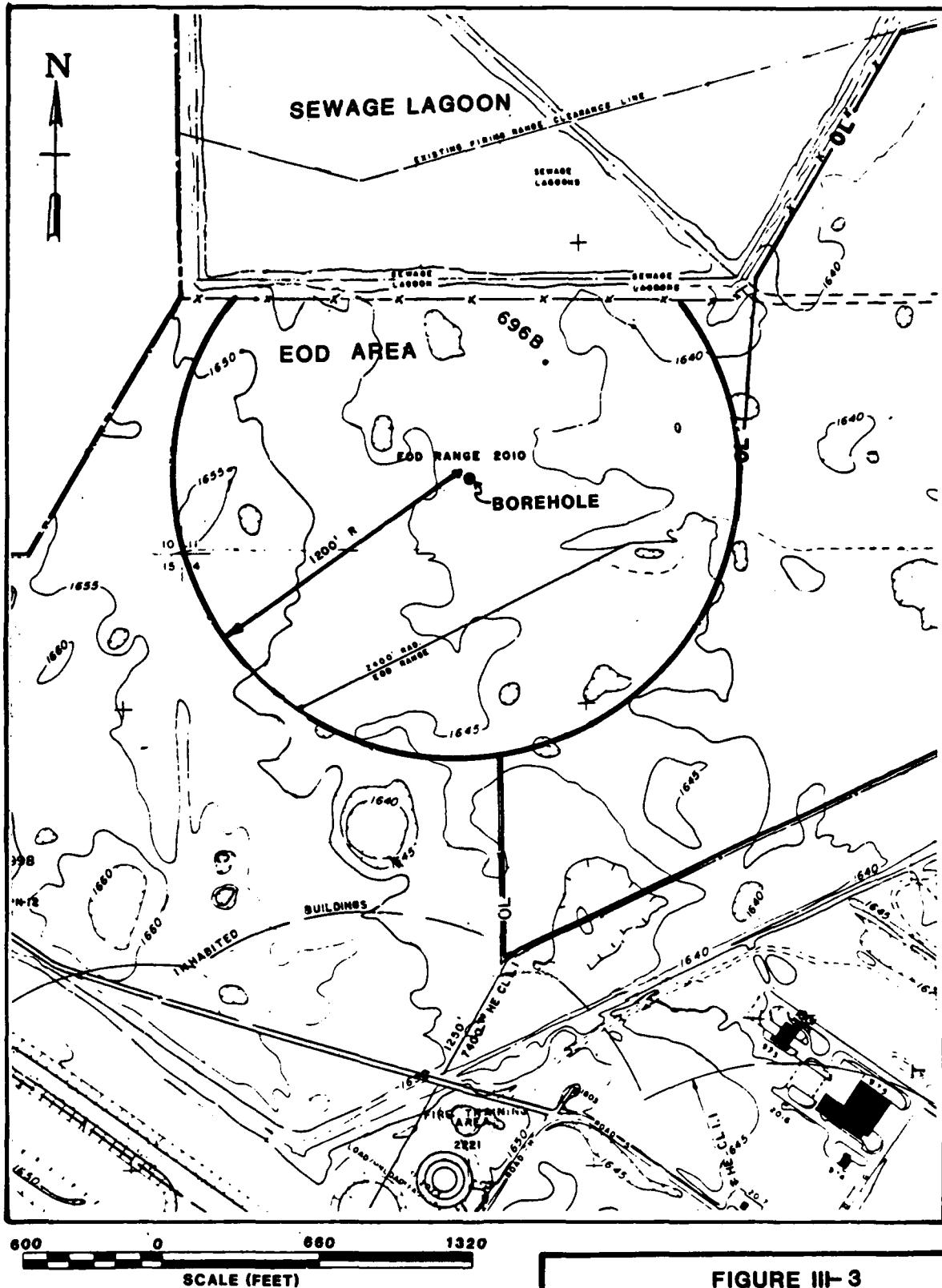


FIGURE III-3
**BOREHOLE IN THE EXPLOSIVE
 ORDNANCE DISPOSAL AREA**
MINOT AIR FORCE BASE

FRED C. HART ASSOCIATES, INC.

3.25-inch inner diameter (ID) hollow-stem auger with a 5.5-inch bit. Hollow-stem augers provide access for the use of a sampling tool for soil sample collection and the installation of the 2.0-inch diameter monitoring wells installed at the site.

Test borings DW-1, DW-3 and DW-4 required the use of a wash-rotary drilling method due to their greater depth. The wash-rotary method uses a head of water to allow for easy drilling and to maintain an open borehole to facilitate split-spoon sampling.

B.5 Soil Sampling Methodology

Soil samples were collected with a standard 2.0-inch ID split-spoon sampling tool driven over a 2.0-foot interval with a 140-pound hammer falling 30 inches. The TOP originally proposed that split-spoon samples be taken at five-foot intervals. However, the presence of numerous sand lenses at varying depths within the till required continuous sampling to accurately characterize the geology. Continuous sampling was used to a depth of 20 feet in boreholes SW-5, SW-6, SW-8, SW-1 and DW-4, and to a depth of 25 feet in borehole SW-9; otherwise, samples were taken at 5-foot intervals. All soil samples were logged in the field by a HART geologist and a portion of the sample was retained for visual record. The borehole log sheets are provided in Appendix D. Only from test boring 1 (TB-1) and TB-2 were portions of samples also retained for chemical analyses.

Samples were retained for chemical analyses from each split-spoon sample taken in both TB-1 in the FTA and TB-2 in the EOD. An aliquot of each split-spoon sample was placed in air-tight 8-oz jars and 40-ml VOA vials and then placed on ice while still on-site. Four samples taken from TB-1 were analyzed for total petroleum hydrocarbons, aromatic and halogenated volatile organic compounds and lead. Two samples taken from TB-2 were analyzed for total petroleum hydrocarbons and priority pollutant (CL5074A/1)

metals. The restrictions on the number of samples to be submitted for analyses were outlined in the TOP. Appendix H contains all results of subsurface soil sample chemical analyses.

Two criteria were used to assess which samples were submitted for laboratory analyses. The first was obvious contamination such as discoloration and odor. Second, samples were screened with the OVA to determine the presence of volatile organic compounds. OVA screening involved placing a sample filled 40-ml VOA vial in a 40°C hot water bath for twenty minutes. An aliquot of air from the headspace within the vial was then withdrawn by syringe for direct injection into the OVA. Any presence of volatile organic compounds greater than 0.1 parts per million (ppm) was indicated by deflection of the needle on the OVA gauge. Relative quantitative results were indicated by the magnitude of the needle's deflection. OVA screening results were used to identify zones of potential contamination by volatile organic compounds. The depths at which samples were taken in the two boreholes, visual descriptions of the samples, OVA screening results and samples submitted to Princeton Testing Laboratories and USAFOEHL for laboratory analyses are outlined in Chapter IV of this report.

In addition to samples retained for visual record and chemical analyses, eight subsurface soil samples were also retained for geotechnical analyses. These samples were also collected with a split-spoon sampler and placed directly in drillers jars. Samples were chosen from a variety of materials with the intent of establishing a varied data base to represent all types of deposits encountered. A list of analyzed samples and summarized results are provided in Chapter IV of this report. This information aided in the lithologic classifications of the materials and in assessing relative permeabilities of materials. J & L Testing of Bridgeville, Pennsylvania was contracted to perform all geotechnical analyses. Complete results of grain size analyses are contained in Appendix H.

Additional samples were also collected for triaxial permeability analysis. These samples were collected using Shelby tubes and hydraulic rig pressure. The ends of the tubes were properly sealed with wax prior to shipping. A list of the Shelby tubes analyzed is provided in Chapter IV of this report, along with the locations and depths at which samples were taken and the type of material contained within each particular Shelby tube. Complete results of triaxial permeability analyses are presented in Appendix H.

B.6 Decontamination Procedures

Proper decontamination procedures were followed during the test boring and soil sampling program. The purpose of the decontamination procedures was two-fold: (1) to limit the transmittal of contaminated materials to "clean areas" such as other test borings and off-site property; and (2) to limit the transmittal of contaminated materials between samples, which would yield false analytical results. The decontamination procedure followed for all sampling apparatus (split-spoons, mixing bowls and trowels) consisted of washing with a mild soap detergent and water, followed by a tap water rinse, a methanol rinse and finally a distilled water rinse. The sampling equipment was allowed to air dry when time permitted.

The decontamination procedure for all other apparatus (drilling equipment such as augers, rods, bits and the rig itself) consisted of steam cleaning the apparatus with tap water. All steam cleaning was conducted on a cement pad, otherwise known as a "wash rack," located outside Building 521. The waste water was allowed to run through the oil/water separation drain located in the center of the cement pad.

C. Sediment Sampling

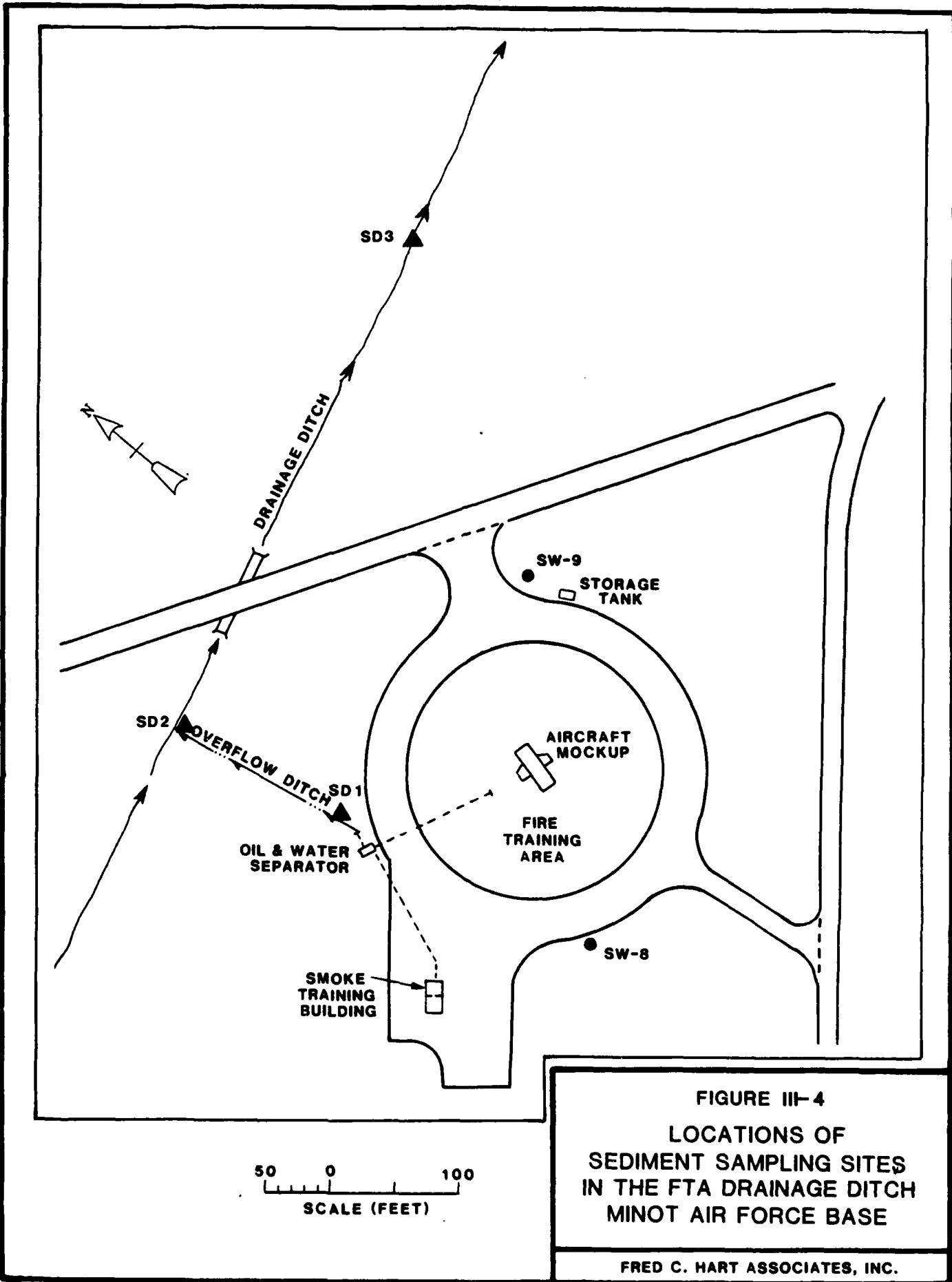
Sediment samples were collected from the drainage ditch leading away from the FTA. The purpose of this sediment sampling was to evaluate potential contamination within this ditch resulting from activities related to the FTA.

C.1 Locations

The locations of the three sediment sampling sites are shown in Figure III-4. Sample site SD-1 is located only a few feet from where the oil/water separator discharges fluid into the drainage ditch. Sample site SD-2 is located approximately 10 to 15 yards west of SD-1, just before the ditch makes a jog to the east and meets the drainage ditch that drains the runways to the south. Sample site SD-3 is located approximately 100 to 150 yards north of where the drainage ditch crosses the FTA access road. These sediment sampling locations were permanently marked with galvanized steel pipes that were driven into the ground and marked with the appropriate numbers with indelible ink.

C.2 Methodology

The three locations were sampled with a hand auger to a depth of one foot. Aliquots of soil from the upper and lower 6-inch segments were placed into air-tight 8-ounce jars and 40-ml VOA vials and then placed on ice while still on-site. As outlined in the TOP, only one sample from each location could be sent for analyses for total petroleum hydrocarbons, aromatic and halogenated volatile organic compounds and lead. Therefore, it was necessary to use the same criteria described in Section B.5 to evaluate which samples were to be submitted for analyses; specifically, obvious contamination and OVA screening results. The results of OVA screening and the samples chosen for chemical analyses are found in Chapter IV of this report. Following screening with an OVA, samples were



shipped by overnight courier to Princeton Testing Laboratories in New Jersey. Appendix H contains a complete set of results for chemical analyses of surface sediment samples.

C.3 Decontamination Procedures

Proper decontamination procedures were followed during sampling to limit the potential for cross contamination between samples. Decontamination procedures followed for all sampling apparatus (buckets, augers, mixing bowls and trowels) consisted of washing with a mild soap detergent and water followed by a tap water rinse, a methanol rinse and finally a distilled water rinse. All sampling equipment was allowed to air dry when time permitted.

D. Ground Water Monitoring Well Installation

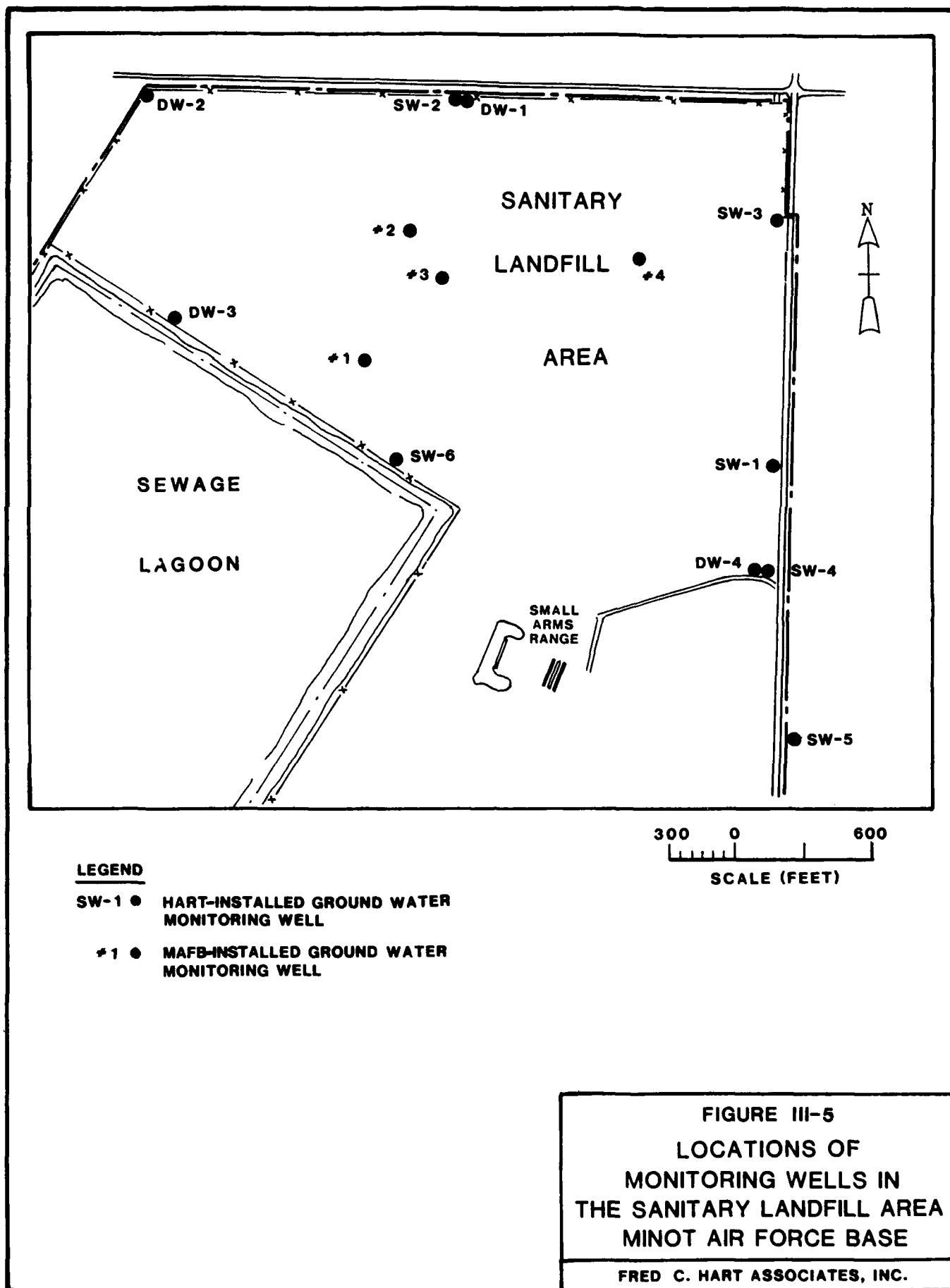
Monitoring wells were installed in both the SLA and the FTA for the purpose of monitoring ground water quality and the hydrostatic properties of the water-bearing sand and gravel deposits.

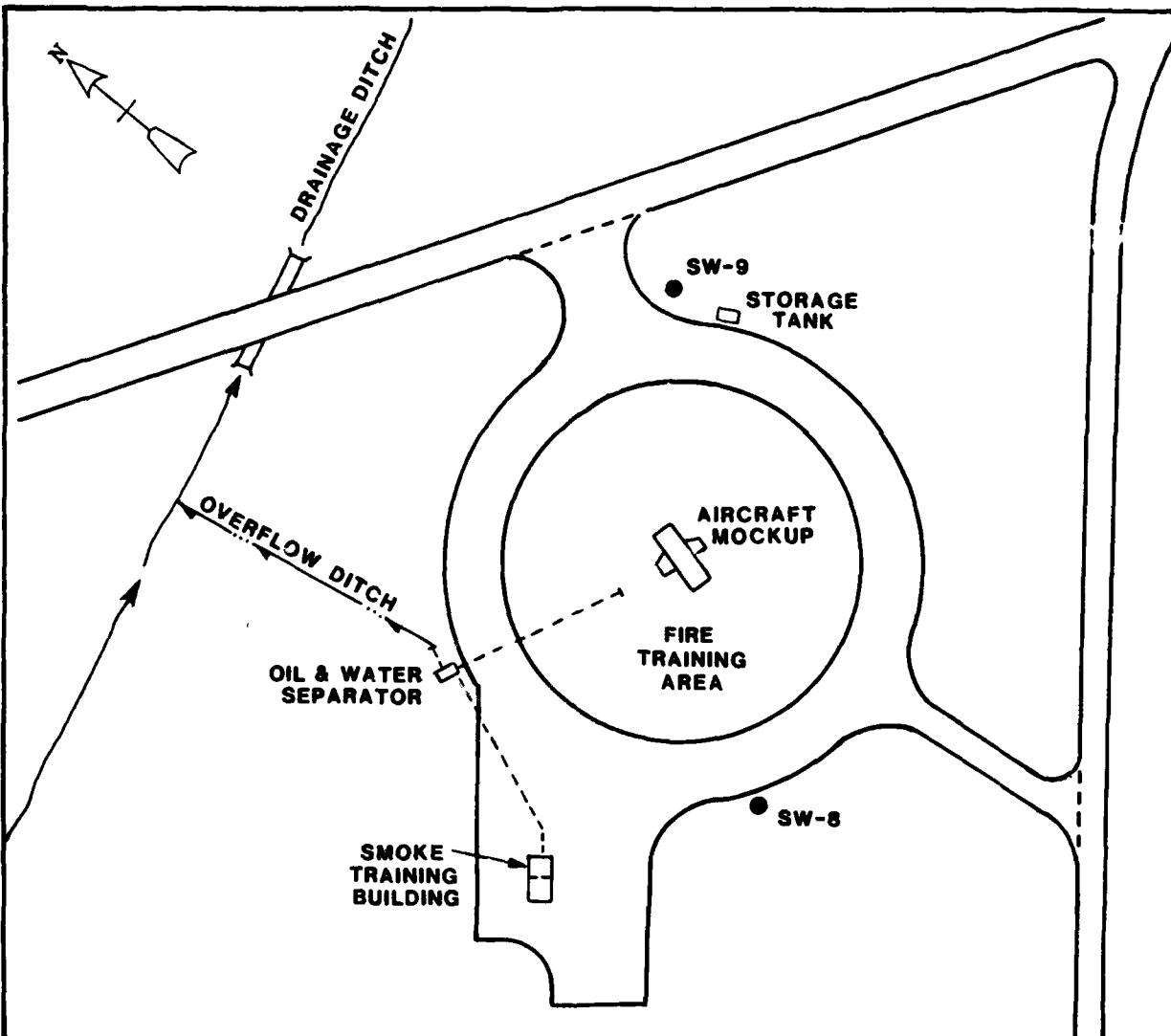
D.1 Locations

The locations of monitoring wells in the SLA are shown in Figure III-5 and the locations of monitoring wells in the FTA are shown in Figure III-6. These monitoring well locations correspond to the test boring locations previously described, as wells were installed either directly in or immediately adjacent to the original test borings.

D.2 Well Construction Methodology and Procedures

The drilling and installation procedures used varied slightly for different wells. The boreholes drilled for the installation of wells SW-2, SW-3 and DW-2 encountered very little sand. It was therefore possible to remove the augers prior to well installation, as the cohesive clays kept the borehole from caving.





50 0 100
SCALE (FEET)

LEGEND

SW-8 • HART-INSTALLED GROUND WATER MONITORING WELL

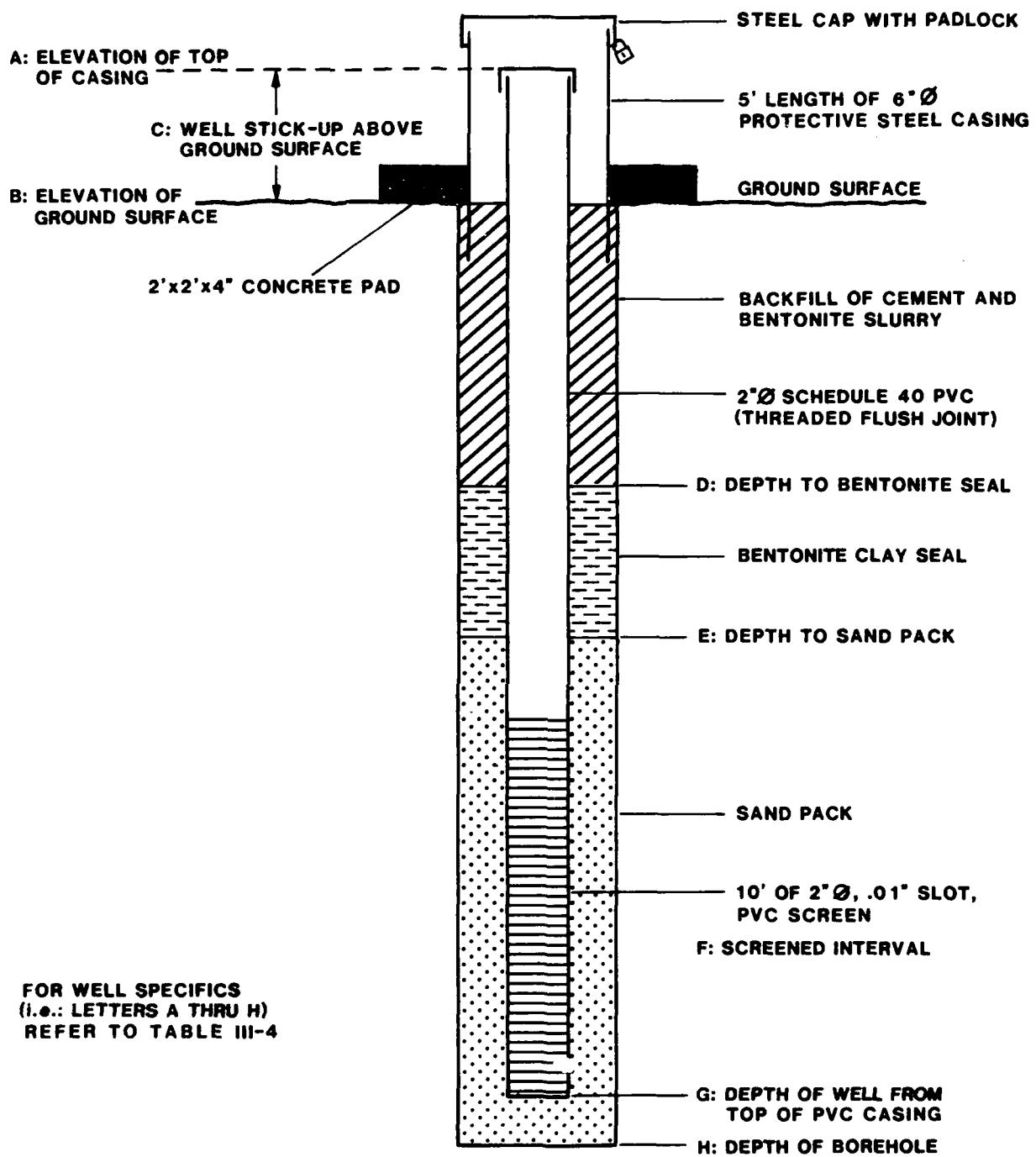
FIGURE III-6
LOCATIONS OF MONITORING WELLS IN THE FIREFIGHTING TRAINING AREA MINOT AIR FORCE BASE

FRED C. HART ASSOCIATES, INC.

Monitoring well DW-3 was the only well installed in a borehole that was drilled by the wash-rotary method. The drilling fluid used with the wash-rotary method begins as fresh water. However, in drilling through 50 feet of till, the fluid accumulated a large amount of clay and silt as mud. Following completion of the borehole to the required depth, the drilling fluid was flushed from the borehole by displacing it with clean water. The drilling fluid applies a "mud cake" or "filter cake" to the sides of the borehole. This mudcake combined with the head of standing water in the hole helped to maintain an open borehole for well installation.

All of the remaining wells were installed through the hollow-stem augers. This procedure involves emplacing the well through the auger and then delivering construction materials (sand, bentonite pellets and grout) down through the augers as the augers are being removed. In shallow wells (20 feet or less), it was possible to simply pour the material down through the augers. In deeper wells (greater than 20 feet), it was necessary to use tremie pipes to ensure that the materials were being delivered to the proper place within the well borehole.

All wells were constructed with 2-inch diameter, schedule 40 PVC screen and casing. The screen consisted of a 10-foot length of 0.010-inch slot size with a bottom plug. A generalized well construction diagram is shown in Figure III-7 and construction specifics are provided in Table III-2. Generally, well construction involved: (1) backfilling the borehole with 0.5 feet of sand (the same sand used for the sand pack) as a base; (2) emplacing the well screen and casing; (3) installing a sand pack in the annular space between the well and borehole walls to a height of 2 feet above the top of the screen; (4) installing a bentonite pellet seal to prevent vertical migration of water into the well (5 feet if space provided, 2 feet otherwise); (5) grouting the remaining annular space with a cement-bentonite slurry; (6) installing a protective steel casing with locking cap around the part of the well that protrudes above the ground surface; and (7) installing a cement pad, 2 feet by 2 feet by 4 inches, around the protective steel casing.



NOT TO SCALE

FIGURE III- 7
SCHEMATIC
WELL CONSTRUCTION DIAGRAM

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WELL CONSTRUCTION DETAILS

<u>WELL #</u>	<u>A* ELEV.</u>	<u>B* TOP OF PVC CASING (FT msL)</u>	<u>C** ELEV. GRND SURFACE (FT msL)</u>	<u>STICK-UP (FT)</u>	<u>D** DEPTH TO BENTONITE SEAL (FT)</u>	<u>E** DEPTH TO SAND PACK (FT)</u>	<u>F*** SCREENED INTERVAL (FT)</u>	<u>G*** DEPTH FROM TOP OF PVC CASING (FT)</u>	<u>H** DEPTH OF BOREHOLE (FT)</u>
SW-1	1630.98	1629	2.2		3	5	10-20	19.60	16.0
SW-2	1634.25	1632	2		6	8	10-20	19.60	20.5
SW-3	1640.07	1638	2		8	13	17-27	27.01	25.5
SW-4	1635.53	1634	2		3	5	8-18	17.87	16.5
SW-5	1634.54	1633	2		4	6	10-20	19.77	18.0
SW-6	1645.81	1643	2.4		5	7	12-22	22.01	20.0
SW-8	1653.33	1651	2		6	8	12-22	21.53	22.0
SW-9	1652.22	1650	2		7	12	15-25	24.57	23.8
DW-1	1634.17	1632	2		31	36	41-51	51.23	50.0
DW-2	1642.54	1641	2		26	31	35-45	45.15	43.5
DW-3	1650.47	1649	1.9		25	30	36-46	45.82	44.0
DW-4	1635.47	1633	2		27	32	39-49	49.22	45.0

* The value in column A was determined from the well elevation survey conducted by Nesdahl Surveying and Engineering P.C. of Minot, ND and are accurate to within 0.01 feet. The value in column B was calculated by subtracting the value in column C from the value in column A and is only accurate to within +/- 0.05 feet.

** The values in columns C,D,E and H are measurements taken during well construction relative to the ground surface. As the ground surface is disturbed during well construction, the values in columns C, D and E should only be considered accurate to within +/- 0.5 feet. Due to the disturbance of the ground surface during well construction and the presence of mud in the borings upon completion of drilling, the values in column H should only be considered accurate to within +/- 1 foot.

*** The value in column G was measured following well completion with a surveyors tape and is accurate to within 0.01 feet. The value in column F is the lower 10 feet of each well (well screens were 10 feet in length) with the numbers rounded to the nearest foot.

D.3 Decontamination Procedures

All drilling equipment, such as augers, rods, bits and the rig itself, were decontaminated to prevent cross-contamination between borings. Well screen, riser pipe and protective casing were also decontaminated prior to well installation. The decontamination procedures followed for all apparatus consisted of steam cleaning the apparatus with water to remove bulk solids. All steam cleaning was conducted on the cement pad outside of Building 521.

D.4 Well Development

Following installation and an appropriate period of time allowed for the set-up of the grout, all monitoring wells were developed in order to disperse and remove formation fines adjacent to the well screen and improve the flow of water into the well. A bailing method was used to develop HART-installed wells. This method consisted of using 1.5-inch diameter, decontaminated stainless steel and teflon bailers in the 2.0-inch diameter wells to surge the water in the well up and down and create turbulence. Teflon bailers were used in SLA shallow wells; stainless steel bailers were used in SLA deep wells and FTA wells. The turbulence created by bailers was sufficient to remove fines from the well screen and the surrounding sand pack. The temperature, pH and conductivity were measured periodically during well development to assess the stability of these parameters. In every case, the development of a well proceeded until the well went dry. Table III-3 summarizes pertinent facts relevant to well development.

E. Ground Water Sampling Program

HART's ground water sampling program conducted at MAFB consisted of the following: (1) sampling the 10 HART installed SLA wells and the 4 previously installed SLA wells and analyses of the samples for total petroleum hydrocarbons, aromatic and halogenated volatile organic compounds, 13 priority pollutant metals, extractable priority pollutant (CL5074A/1)

TABLE III-3
WELL DEVELOPMENT DATA

<u>WELL #</u>	<u>DATE DEVELOPED</u>	<u>GALLONS REMOVED</u>	<u>pH</u>	<u>SPECIFIC CONDUCTANCE UMHOS/CM</u>	<u>TEMPERATURE C</u>
SW-1	10-28-86	1.0	6.85	1650	8
		3.3	7.35	1780	8
		6.7	6.95	1890	8
		13.3	6.70	1820	8
SW-2	10-27-86	0.5	7.1	2140	8
SW-3	10-28-86	0.8	6.5	5760	8
		1.5	6.6	6430	8
SW-4	10-28-86	0.8	8.5	5420	8
		2.0	8.25	5400	8
SW-5	10-28-86	0.8	7.0	7990	8
		2.0	7.0	7020	8
SW-6	10-27-86	0.8	6.4	6450	8
		3.3	6.2	6580	8
SW-8	10-28-86	0.8	6.9	2840	8
		3.3	7.1	2770	8
SW-9	10-28-86	0.8	7.15	17870	8
		5.0	7.15	17720	8
DW-1	10-27-86	5.8	7.3	1830	8
DW-2	10-27-86	3.3	7.5	1710	8
		10.0	6.9	1710	8
DW-3	10-27-86	1.7	7.8	2730	8
		4.2	7.4	2730	8
DW-4	10-28-86	1.7	9.35	1630	8
		4.2	8.60	2360	8
		6.7	7.30	3710	8

(CL5022B/3)

organics, total dissolved solids and common anions; (2) sampling the 2 HART-installed FTA wells and analyses of the samples for total petroleum hydrocarbons, aromatic and halogenated volatile organic compounds and lead; and (3) sampling the existing Corps of Engineers (COE) abandoned water production well (located on the eastern boundary of the base between the base golf course and State Highway Number 83) and analyses of the sample for aromatic and halogenated volatile organic compounds, total petroleum hydrocarbons, total dissolved solids, 13 priority pollutant metals and common anions. In addition to laboratory analyses, temperature, pH and conductivity were also measured for all samples in the field. The procedures used to obtain temperature, pH and conductivity measurements are provided in Appendix F.1.

Water samples were withdrawn from the well using a decontaminated teflon bailer. Water samples were placed into laboratory-prepared, air-tight sample bottles. All ground water sample bottles were placed on ice while on-site and then placed in sealed coolers and shipped by overnight courier to Princeton Testing Laboratories and USAFOEHL. Relevant ground water sampling data and results of analyses are presented in Chapter IV of this report.

In order to determine if free-floating hydrocarbons were present on the water surface prior to sampling, a paste and tape method was utilized. This method involves applying a hydrocarbon sensitive paste as a thin film on a measuring tape. The tape is then lowered down into the well. The paste will only be dissolved in the presence of free hydrocarbons. No free hydrocarbons were detected in any of the monitoring wells.

It was necessary to prepare monitoring wells prior to sampling in order to obtain a sample that is representative of the ground water within the surrounding formation. This preparation entails removing all of the water which is standing in the casing and grabbing a sample from water that has recently been recharged to the well from the surrounding formation. To accomplish this, the depth of the water from the top of (CL5074A/1)

casing was measured. This value was used in conjunction with the total casing length to determine the height of the water column and, thus, the volume of standing water in the well. It is a convention to remove three to five times the volume of water standing in the well prior to sampling. However, in every case HART was able to bail the wells dry because of the low yield of the formations; therefore, the water that recharged into the well from the surrounding formation after pre-sampling bailing was considered representative of the water of the surrounding formation. Table III-4 summarizes relevant pre-sampling bailing data.

To prevent cross-contamination of wells, bailers were decontaminated prior to bailing and prior to sampling. In addition, a suitable length of polypropylene rope was dedicated to each well prior to development and was used during development, pre-sampling bailing and sampling.

F. Surface Water Sampling Program

Four samples were collected from surface water present within the SLA. The locations of these samples are shown in Figure III-8. These samples were analyzed in the field for temperature, pH and conductivity. In addition to field analyses, a grab sample was obtained for laboratory analyses for total petroleum hydrocarbons, aromatic and halogenated volatile organic compounds, 13 priority pollutant metals, extractable priority pollutant organics, total dissolved solids and common anions. Water samples were collected in laboratory-prepared, air-tight sample bottles. These sample bottles were packed on ice while on-site, sealed in a cooler and delivered in person to Princeton Testing Laboratories in New Jersey. Relevant surface water sampling data are presented in Chapter IV of this report. Results of laboratory analyses are found in Appendix H.

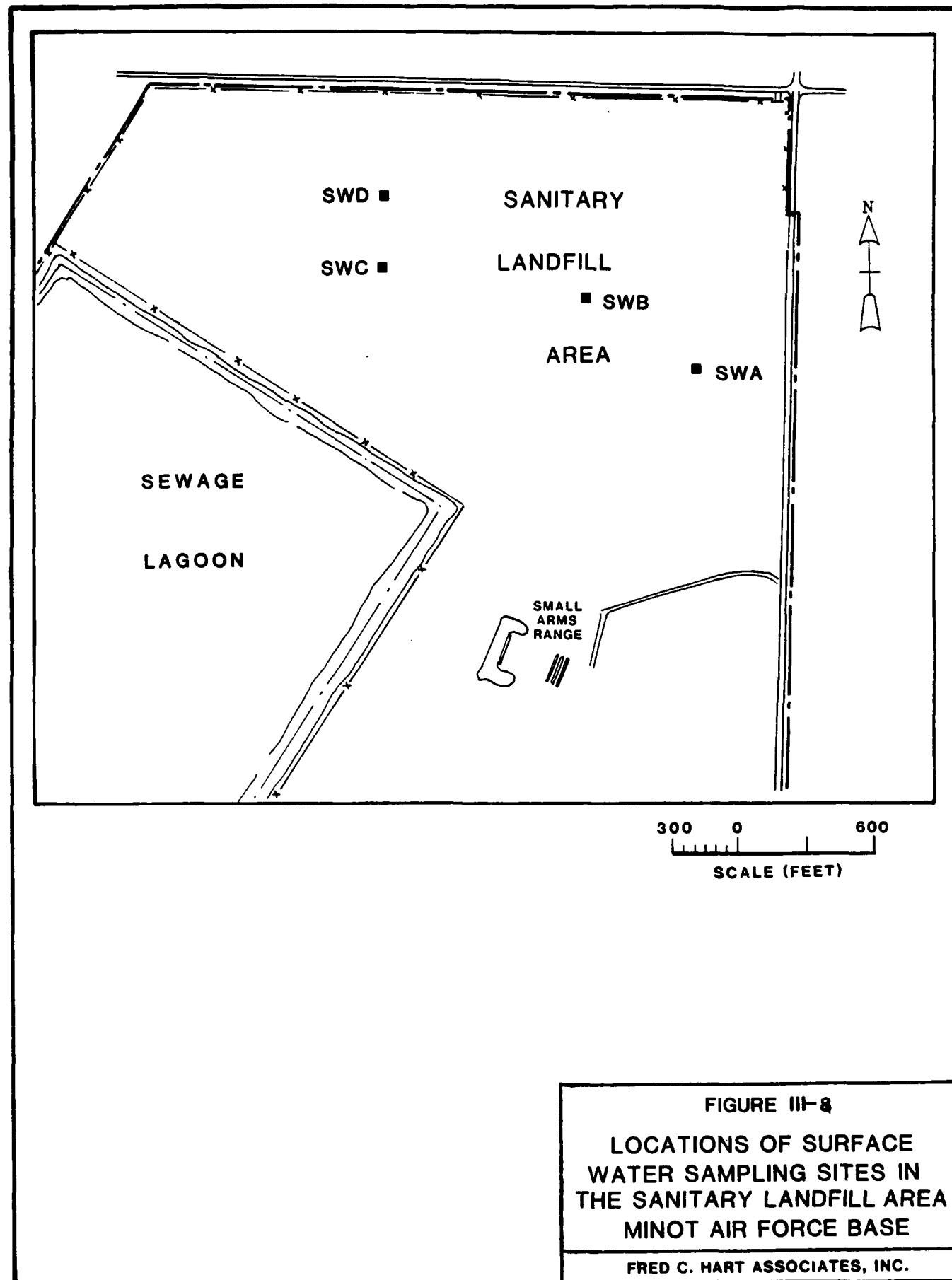
TABLE III-4

PRE-SAMPLING BAILING DATA

<u>WELL #</u>	<u>DATE BAILED</u>	<u>WATER LEVEL BELOW TOP OF PVC CASING</u>	<u>DEPTH OF WELL FROM TOP OF PVC CASING</u>	<u>HEIGHT OF COLUMN OF WATER</u>	<u>GALLONS OF STANDING WATER</u>	<u>GALLONS REMOVED TO BAIL DRY</u>	<u># OF WELL VOLUMES REMOVED</u>
SW-1	10-29-86	6.92	19.60	12.68	2.03	15.0	7.39
*SW-2	10-29-86	19.23	19.65	0.42	0.07		
SW-3	10-29-86	18.44	27.01	8.57	1.37	2.7	1.97
SW-4	10-29-86	8.40	17.87	9.47	1.52	7.5	4.95
SW-5	10-29-86	8.20	19.77	11.57	1.85	3.3	1.78
SW-6	10-29-86	6.55	22.01	15.46	2.47	3.2	1.29
SW-8	10-29-86	7.87	21.53	13.66	2.19	3.2	1.46
SW-9	10-29-86	7.97	24.57	16.60	2.66	8.0	3.01
DW-1	10-29-86	9.89	51.23	41.34	6.61	7.5	1.13
DW-2	10-29-86	10.08	45.15	35.07	5.61	20.0	3.56
DW-3	10-29-86	35.39	45.82	10.43	1.67	1.7	1.02
DW-4	10-29-86	10.78	49.22	38.44	6.15	11.0	1.79
MW-1	10-29-86	3.28	32.00	28.72	4.60	10.0	2.18
MW-2	10-29-86	6.78	30.60	23.82	3.81	9.2	2.41
MW-3	10-29-86	6.00	31.20	25.20	4.03	20.0	4.96
MW-4	10-30-86	11.27	39.54	28.27	4.52	13.0	2.87
**COE							

* SW-2 was not bailed due to lack of water

** The COE well was not bailed due to access and time constraints
 (Delays in the removal of well-head pumping equipment and the large volume
 of water to be removed as required for pre-sampling purging prevented
 bailing at the COE well)



G. Surveying

The well elevations (reference mark on top of PVC casing) and horizontal locations were surveyed by Nesdahl Surveying and Engineering, P.C. of Minot, North Dakota. The results of the elevation survey are presented in Table III-2.

H. Hart QA/QC Field Procedures and Reliability of Results

All field equipment used during the HART investigation was subject to proper decontamination procedures as detailed in this chapter. All sampling equipment (bailers, trowels, buckets, mixing bowls, etc.) was decontaminated by the same procedures. Two equipment blanks were collected to check the integrity of these procedures.

One equipment blank was collected by pouring distilled water over a decontaminated bailer during sampling of the SLA monitoring wells. This sample was sent for analyses with the SLA ground water samples for identical parameters and was given the HART sample identifier MAFB, SLA, Equipment Blank, HART 015 and the PTL sample identifier 015. The only analysis parameter detected in sample 015 was nitrite, which had a concentration of 0.04 mg/l. This concentration of nitrite, however, does not represent significant equipment contamination, as nitrite was not found in any of the ground water samples.

The second equipment field blank was collected by pouring distilled water through a decontaminated bailer during sampling of the FTA monitoring wells. This sample was sent for analyses with the FTA ground water samples and was given the HART sample identifier MAFB, FTA, Equipment Blank, HART 011, and the PTL sample identifier 011. This sample was analyzed for volatile organic compounds, total petroleum hydrocarbons and lead. No analysis parameters were detected in the FTA equipment blank.

Daily calibration procedures are provided in Appendix F.1. The OVA also was zeroed daily to account for varying background levels. The pH and conductivity meters were calibrated daily to laboratory prepared standards.

I. COE Well Sampling and Reliability of Results

The purpose of sampling the COE well was to determine the concentrations of specified parameters in the ground water obtained from this well. However, due to the poor condition of this well, proper sampling protocol could not be adhered to.

The initial inspection of this well indicated that the pump and pumping system, which had been out of service for a number of years, was still in place but inoperable. At HART's request, MAFB personnel dismantled the COE well pump and pumping system. This task was not completed until October 30, the final day of ground water sampling. However, even with the pump and pumping system removed, access to the well was limited by non-removable casing adapters.

The depth of the well is approximately 125 ft and, when the well was sampled, the depth of the water from the top of the well casing was 44.49 ft; thus, approximately 80 ft of standing water was present in the well. Proper sampling protocol involves the removal of at least three well volumes of water prior to sampling. The only method for purging water from the well (available to HART at the time) was bailing with teflon or stainless steel bailers. The removal of this volume of water from the COE well by bailing was unachievable at the time. Instead, a sample was obtained from the standing water in the well. This sample was given the HART identifier MAFB, COE, GW-1, HART 022 and the PTL sample identifier SN022. The results of analyses of this sample are contained in Appendix H of this report. Because proper sampling protocol could not be followed, the analyses results of this sample are considered unreliable.

DISCUSSION OF RESULTS AND SIGNIFICANCE OF FINDINGS

This chapter presents the results of the HART investigation conducted at MAFB. The reliability of the results, interpretation of the potential extent of contamination and an evaluation of the potential hazards associated with such a problem are also discussed.

A. Discussion of Field Sample Analytical Results

A sampling plan for each of the three areas was developed to provide an adequate data base from which interpretations and conclusions were made regarding potential contamination. The sampling plans were presented in the Technical Operations Plan (Appendix L) and approved by USAFOEHL personnel. A discussion of the sampling plans and subsequent results for the three areas of investigation -- the Sanitary Landfill Area (SLA), the Firefighting Training Area (FTA) and the Explosive Ordnance Disposal Area (EOD) -- are presented in this section.

Princeton Testing Laboratory (PTL) of Princeton, New Jersey was used throughout this investigation. PTL was responsible for the following analyses: priority pollutant metals, aromatic and halogenated volatile organic compounds, extractable priority pollutant organics, total dissolved solids, common anions and total petroleum hydrocarbons. PTL performed the required analyses on surface water, ground water, subsurface soil and surface sediment samples. The reliability of the test methods used by PTL is discussed in Sections B and C. Appendix H contains the laboratory analyses results as received from PTL by HART. Table IV-1 provides a cross-reference of HART sample identifiers to PTL sample identifiers and job numbers. Table IV-1 also provides a cross-reference of analytical results reports to the various subdivisions of Appendix H.

The results for volatile organic and extractable priority pollutant organic compounds analyses were reported in micrograms per liter (ug/l) for water samples and micrograms per kilogram (ug/kg) for sediment and soil samples. The results for metals and total petroleum hydrocarbon (CL5142A/1)

TABLE IV-1
SAMPLE IDENTIFIER AND ANALYTICAL RESULTS CROSS-REFERENCE

Sample-Identifier Cross-Reference				Cross-Reference Analytical Results Reports To Appendices						BASE/ NEUTRAL EXTRACTABLE ORGANICS	
<u>HART</u>	<u>PTL</u>	<u>POLY- METALS</u>	<u>SAMPLE NUMBER</u>	PRIORITY	TOTAL DISSOLVED	TOTAL	AROMATIC	HALOGENATED	ACID	EXTRACTABLE	BASE/ NEUTRAL EXTRACTABLE ORGANICS
				<u>POLLUTANT</u>	<u>SOLIDS AND COMMON ANIONS</u>	<u>PETROLEUM HYDROCARBONS</u>	<u>VOLATILE ORGANICS</u>	<u>VOLATILE ORGANICS</u>	<u>ORGANICS</u>	<u>ORGANICS</u>	
MAFB, SW-1 GW-1 HART 001	SN001	86GW3523	H.6	H.8	H.4	H.1.b	H.1.c.	H.1.c.	H.3.c	H.3.d	
MAFB, DW-1 GW-1 HART 003	SN003	86GW3523	H.6	H.8	H.4	H.1.b	H.1.c	H.1.c	H.3.c	H.3.d	
MAFB, SW-3 GW-1 HART 004	SN004	86GW3506	H.6	H.8	H.4	H.1.a	H.1.a	H.1.a	H.3.a	H.3.b	
MAFB, SW-4 GW-1 HART 005	SN005	86GW3506	H.6	H.8	H.4	H.1.a	H.1.a	H.1.a	H.3.a	H.3.b	
MAFB, SW-5 GW-1 HART 006	SN006	86GW3506	H.6	H.8	H.4	H.1.a	H.1.a	H.1.a	H.3.a	H.3.b	
MAFB, SW-6 GW-1 HART 007	SN007	86GW3523	H.6	H.8	H.4	H.1.b	H.1.c	H.1.c	H.3.c	H.3.d	

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TABLE IV-1 (Continued)

SAMPLE IDENTIFIER AND ANALYTICAL RESULTS CROSS-REFERENCE

Sample-Identifier Cross-Reference						Cross-Reference Analytical Results Reports To Appendices					
HART	PTL	PRIORITY	TOTAL DISSOLVED	TOTAL	AROMATIC	HALOGENATED	ACID	BASE/			
SAMPLE	SAMPLE	POLLUTANT	SOLIDS AND	PETROLEUM	VOLATILE	VOLATILE	EXTRACTABLE	NEUTRAL			
NUMBER	NUMBER	METALS	COMMON ANIONS	HYDROCARBONS	ORGANICS	ORGANICS	ORGANICS	EXTRACTABLE			
<u>MAFB, SW-8</u>	<u>SN008</u>	<u>86643523</u>	<u>H.6</u>	<u>NA</u>	<u>H.4</u>	<u>H.1.b</u>	<u>H.1.c</u>	<u>ORGANICS</u>	<u>ORGANICS</u>	<u>ORGANICS</u>	<u>ORGANICS</u>
GW-1			(Lead only)								NA
HART 008											
MAFB, SW-9	SN009	86643506	H.6 (Lead only)	NA	H.4	H.1.a	NA	NA	NA	NA	
GW-1											
HART 009											
MAFB, SW-9	SN010	86643506	H.6 (Lead only)	NA	H.4	H.1.a	NA	NA	NA	NA	
GW-2											
HART 010											
MAFB, FTA Ground Water Equipment Blank	SN011	86643506	H.6 (Lead only)	NA	H.4	H.1.a	NA	NA	NA	NA	
Hart 011											
MAFB, DW-2	SN012	86643506	H.6	H.8	H.4	H.1.a	H.3.a	H.3.b			
GW-1											
HART 012											
MAFB, DW-3 GS-1	SN013	86643523	H.6	H.8	H.4	H.1.b	H.1.c	H.3.c	H.3.d		
HART 013											

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TABLE IV-1 (Continued)

SAMPLE IDENTIFIER AND ANALYTICAL RESULTS CROSS-REFERENCE

Sample-Identifier Cross-Reference	Cross-Reference Analytical Results Reports To Appendices										
	PTL SAMPLE NUMBER	PTL JOB NUMBER	PRIORITY POLLUTANT METALS	TOTAL DISSOLVED SOLIDS AND COMMON ANIONS			AROMATIC PETROLEUM HYDROCARBONS			ACID EXTRACTABLE ORGANICS	NEUTRAL EXTRACTABLE ORGANICS
				COMMON ANIONS	HYDROCARBONS	ORGANICS	VOLATILE ORGANICS	AROMATIC ORGANICS			
MAFB, DW-4 GW-1 HART 014	SN014	866M3523	H.6	H.8	H.4	H.1.b	H.1.c	H.3.c	H.3.d		
MAFB, SLA Equipment Blank HART 015	SN015	866M3506	H.6	H.8	H.4	H.1.a	H.1.a	H.3.a	H.3.b		
MAFB, MM-1 GW-1 HART 017	SN017	866M3523	H.6	H.8	H.4	H.1.b	H.1.c	H.3.c	H.3.d		
MAFB, MM-2 GW-1 HART 018	SN018	866M3523	H.6	H.8	H.4	H.1.b	H.1.c	H.3.c	H.3.d		
MAFB, MM-3 GW-1 HART 019	SN019	866M3523	H.6	H.8	H.4	H.1.b	H.1.c	H.3.c	H.3.d		
MAFB, MM-4 GW-1 HART 020	SN020	866M3523	H.6	H.8	H.4	H.1.b	H.1.c	H.3.c	H.3.d		

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TABLE IV-1 (Continued)

SAMPLE IDENTIFIER AND ANALYTICAL RESULTS CROSS-REFERENCE

Sample-Identifier Cross Reference							Cross-Reference Analytical Results Reports To Appendices						
HART SAMPLE NUMBER	PTL SAMPLE NUMBER	JOB NUMBER	PRIORITY POLLUTANT METALS	TOTAL DISSOLVED SOLIDS AND COMMON ANIONS	TOTAL PETROLEUM HYDROCARBONS	AROMATIC VOLATILE ORGANICS	HALOGENATED VOLATILE ORGANICS	ACID ORGANICS	EXTRACTABLE ORGANICS	BASE/ NEUTRAL ORGANICS			
MAFB, DW-5 GW-1 HART 021	SN021	86GM3523	H.6	H.8	H.4	H.1.b	H.1.c	H.3.c		H.3.d			
MAFB, COE GW-1 HART 022	SN022	86GM3523	H.6	H.8	H.4	H.1.b	H.1.c	H.3.c		H.3.d			
MAFB, SMA S-1 HART 023	SN023	86GM3523	H.6	H.8	H.4	H.1.d	H.1.e	H.3.e		H.3.f			
MAFB, SAB S-1 HART 024	SN024	86GM3523	H.6	H.8	H.4	H.1.d	H.1.e	H.3.e		H.3.f			
MAFB, SAC S-1 HART 025	SN025	86GM3523	H.6	H.8	H.4	H.1.d	H.1.e	H.3.e		H.3.f			
MAFB, SAD S-1 HART 026	SN026	86GM3523	H.6	H.8	H.4	H.1.d	H.1.e	H.3.e		H.3.f			
MAFB, SME S-1 HART 027	SN027	86GM3523	H.6	H.8	H.4	NA	NA	H.3.e		H.3.f			

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(CL5141A/9)

TABLE IV-1 (Continued)

SAMPLE IDENTIFIER AND ANALYTICAL RESULTS CROSS-REFERENCE

Sample-Identifier Cross-Reference							Cross-Reference Analytical Results Reports To Appendices						
HART SAMPLE NUMBER	PTL SAMPLE NUMBER	PTL JOB NUMBER	PRIORITY POLLUTANT METALS	TOTAL DISSOLVED SOLIDS AND COMMON ANIONS			TOTAL PETROLEUM HYDROCARBONS	AROMATIC VOLATILE ORGANICS	HALOGENATED VOLATILE ORGANICS	ACID EXTRACTABLE ORGANICS	NEUTRAL EXTRACTABLE ORGANICS		
				COMMON ANIONS	HYDROCARBONS	ORGANICS							
MAFB, TB-1 SS-2, 5'-7' HART 001	HART 001	866W3440	H.7 (Lead only)	NA	NA	NA	H.5	H.2	H.2	NA	NA		
MAFB, TB-1 SS-3, 10'-12' HART 002	HART 002	866W3440	H.7 (Lead only)	NA	NA	NA	H.5	H.2	H.2	NA	NA		
MAFB, TB-1 SS-4, 15'-17' HART 003	HART 003	866W3440	H.7 (Lead only)	NA	NA	NA	H.5	H.2	H.2	NA	NA		
MAFB, TB-1 SS-5, 20'-22' HART 004	HART 004	866W3440	H.7 (Lead only)	NA	NA	NA	H.5	H.2	H.2	NA	NA		
MAFB, SD-1 S-2, 0.5'-1.0' HART 005	HART 005	866W3440	H.7 (Lead only)	NA	NA	NA	H.5	H.2	H.2	NA	NA		
MAFB, SD-2 S-1, 0-0.5' HART 006	HART 006	866W3440	H.7 (Lead only)	NA	NA	NA	H.5	H.2	H.2	NA	NA		
MAFB, SD-3 S-1, 0-0.5' HART 007	HART 007	866W3440	H.7 (Lead only)	NA	NA	NA	H.5	H.2	H.2	NA	NA		

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(CL5141A/9)

TABLE IV-1 (Continued)

SAMPLE IDENTIFIER AND ANALYTICAL RESULTS CROSS-REFERENCE

Sample-Identifier Cross-Reference							Cross-Reference Analytical Results Reports To Appendices						
HART SAMPLE NUMBER	PTL SAMPLE NUMBER	PTL JOB NUMBER	PRIORITY POLLUTANT METALS	TOTAL DISSOLVED SOLIDS AND COMMON ANIONS		TOTAL PETROLEUM HYDROCARBONS	AROMATIC VOLATILE ORGANICS	HALOGENATED VOLATILE ORGANICS	ACID EXTRACTABLE ORGANICS	NA	NA	BASE/ NEUTRAL EXTRACTABLE ORGANICS	
				PTL	JOB NUMBER								
HAFB, SD-4 S-1, 0.5'-1.0' HART 008*	HART 008	86G0440	H.7 (Lead only)	NA		H.5	H.2	H.2	NA	NA	NA	NA	
HAFB, TB-2 SS-2, 5'-7', HART 009	HART 009	86G0441	H.7	NA		H.5	NA	NA	NA	NA	NA	NA	
HAFB, TB-2 SS-5, 18'-20', HART 010	HART 010	86G0441	H.7	NA		H.5	NA	NA	NA	NA	NA	NA	
HAFB, TB-2 SS-6, 18'-20', HART 011	HART 011	86G0441	H.7	NA		H.5	NA	NA	NA	NA	NA	NA	

Legend:

- HAFB - Minot Air Force Base
- GW - Ground Water
- SW - Shallow well or Surface water
- DW - Deep Well
- SN - Sample Number
- PTL - Princeton Testing Laboratory
- S - Sample
- TB - Test Boring
- SS - Soil Sample
- * - Sample incorrectly labelled "SD-4, S-1", correct sample identifier is "SD-2, S-2."

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analyses were reported in milligrams per liter (mg/l) for water samples and milligrams per kilogram (mg/kg) for sediment and soil samples. The results for common anion and total dissolved solids analysis of water samples were reported in mg/l.

A.1 The Sanitary Landfill Area Sampling Program and Results

The sampling plan for the SLA included ground water and surface water sampling. Samples were field tested for pH, conductivity and temperature and were analyzed by the laboratory for total petroleum hydrocarbons, extractable priority pollutant organics, 13 priority pollutant metals, total dissolved solids and common anions. Field analytical procedures are provided in Appendix F.1.

A.1.a Surface Water. Four locations were chosen at the SLA to sample standing surface water within several shallow depressions and unfilled trenches. A discussion of the sampling methodology is contained within Chapter III of this report. Surface water sampling data is summarized in Table IV-2 and the locations of the four surface water sampling sites is shown in Figure III-8. Sample 027 is a duplicate of sample 023, thus a total of five samples were sent for laboratory analyses. Volatile organic analyses were not performed on sample 027. The results of field and laboratory analyses are shown in Table IV-3. A summary of the results for constituents detected in the laboratory analyses is included in Table IV-4.

Of the common anions analyzed, all were found to be present in concentrations above the detection level (ADL) in at least one of the surface water samples. Surface water samples 023 and duplicate 027 were both found to contain all of the common anions in ADL concentrations. Chloride, fluoride, bromide, nitrate nitrogen and sulfate were found in ADL concentrations in 100% of the surface water samples and nitrite nitrogen and phosphate were found in ADL concentrations in 40% and 60% of the surface water samples, respectively. Sulfate was the dominant anion in these samples, accounting for approximately 90% of the total of the (CL5142A/1)

TABLE IV-2
SURFACE WATER SAMPLING DATA

SAMPLE	DATE SAMPLE TAKEN	pH	SPECIFIC COND. UMHOS/CM	TEMP. C	SAMPLE SENT FOR ANALYSIS
SW-A	11-2-86	9.25	6010	8	X
SW-B	11-2-86	7.45	3040	8	X
SW-C	11-2-86	8.25	5080	8	X
SW-D	11-2-86	8.05	3630	8	X

X = Sample sent to Princeton Testing Laboratories.

(CL5022B/4)

TABLE IV-3

SLA SURFACE WATER SAMPLING
FIELD AND LABORATORY ANALYTICAL RESULTS

<u>Parameter</u>	<u>Detection Level</u>	<u>HART Identifier</u> <u>Laboratory Identifier</u>					<u>Units</u>
		<u>SWA SNO23</u>	<u>SWB SNO24</u>	<u>SWC SNO25</u>	<u>SWD SNO26</u>	<u>SWE* SNO27</u>	
Priority Pollutant Metals							
Beryllium	0.05	ND	ND	ND	ND	ND	mg/1
Cadmium	0.005	ND	ND	ND	ND	ND	mg/1
Chromium	0.02	ND	ND	ND	ND	ND	mg/1
Copper	0.02	0.03	ND	0.04	0.03	0.04	mg/1
Nickel	0.01	0.016	0.097	0.085	ND	0.014	mg/1
Lead	0.02	ND	ND	ND	ND	ND	mg/1
Zinc	0.02	0.03	0.04	0.06	0.06	0.22	mg/1
Arsenic	0.01	ND	ND	ND	ND	ND	mg/1
Silver	0.01	ND	ND	ND	ND	ND	mg/1
Antimony	0.10	ND	ND	ND	ND	ND	mg/1
Selenium	0.01	ND	ND	ND	ND	ND	mg/1
Thallium	0.01	ND	ND	ND	ND	ND	mg/1
Mercury	0.001	ND	ND	ND	ND	ND	mg/1
Common Anions							
Chloride	1.0	400	120	180	50	380	mg/1
Fluoride	0.1	1.5	1.3	1.6	1.5	1.5	mg/1
Bromide	0.1	2.8	311	2.7	1.8	6.8	mg/1
Nitrate Nitrogen	0.1	0.25	0.24	0.25	0.21	1.05	mg/1
Nitrite Nitrogen	0.001	0.08	ND	ND	ND	0.10	mg/1
Phosphate	0.1	0.10	0.96	ND	ND	0.22	mg/1
Sulfate	1.0	2,400	1,100	3,300	3,500	2,400	mg/1
Total Dissolved Solids	2.0	4,460	2,596	4,782	3,878	4,761	mg/1
Total Petroleum Hydrocarbons	0.5	ND	ND	ND	ND	ND	mg/1
Aromatic Volatile Organics	2.0	ND	ND	ND	ND	NR	ug/1
Halogenated Volatile Organics	1-20	ND	ND	ND	ND	NR	ug/1
Acid Extractable Organics	10-50	ND	ND	ND	ND	ND	ug/1
Base/Neutral Extractable Organics	10-80	ND	ND	ND	ND	ND	ug/1
pH	NA	9.25	7.45	8.25	8.05	9.25	pH units
Specific Conductance	NA	6,010	3,040	5,080	3,630	6010	umhos/cm
Temperature	NA	8	8	8	8	8	°C

Legend appears on next page.

(CL5022B/4)

TABLE IV-3 (Continued)

SLA SURFACE WATER SAMPLING
FIELD AND LABORATORY ANALYTICAL RESULTSLegend

ND - Not Detected

NA - Not Applicable

* - SWE is a blind duplicate of SWA

NR - Volatile Organic Analysis was not run on sample SWE.

mg/l - milligrams/liter

ug/l - micrograms/liter

umhos/cm - micromhos/centimeter

(CL5022B/4)

TABLE IV-4

SLA SURFACE WATER SAMPLING RESULTS FOR DETECTED CONSTITUENTS

<u>Detected Constituent</u>	<u>Percentage of Samples Constituent Detected</u>	<u>No. of Positive Identifications/ Total No. of Samples</u>	<u>Range of Detected Concentrations (mg/l)</u>
Common Anions			
Chloride	100	(5/5)	50 - 400
Fluoride	100	(5/5)	1.3 - 1.6
Bromide	100	(5/5)	1.8 - 311
Nitrate Nitrogen	100	(5/5)	0.21 - 1.05
Nitrite Nitrogen	40	(2/5)	0.08 - 0.10
Phosphate	60	(3/5)	0.10 - 0.96
Sulfate	100	(5/5)	1100 - 3500
Priority Pollutant Metals			
Copper	80	(4/5)	0.03 - 0.04
Nickel	80	(4/5)	0.014 - 0.097
Zinc	100	(5/5)	0.03 - 0.22
Total Dissolved Solids	100	(5/5)	2596 - 4782

Legend

mg/l - milligrams/liter

(CL5022B/4)

detected concentrations of common anions in surface water samples. Surface water samples contained concentrations of common anions ranging from 1,534 to 3,554 mg/l.

Of the 13 priority pollutant metals, only zinc, copper and nickel were found in ADL concentrations in the surface water samples. Zinc was present in 100%, copper in 80% and nickel in 80% of the samples. Total dissolved solids concentrations of the surface water samples ranged from 2,596 to 4,782 mg/l and averaged 4,095 mg/l. Total petroleum hydrocarbons, aromatic and halogenated volatile organic compounds and extractable priority pollutant organics were not found in ADL concentrations in any of the surface water samples.

A.1.b Ground Water. Ground water samples were obtained from the four deep (>30 feet) and six shallow, HART-installed monitoring wells surrounding the perimeter of the SLA. Locations and pertinent facts concerning monitoring wells are illustrated and summarized in Figures III-5 and III-7 and in Table III-2. In addition to the HART-installed monitoring wells, samples were obtained from the four previously installed USAF monitoring wells which are located within the boundaries of the SLA. With the exception of HART monitoring well SW-2, all of the SLA monitoring wells were sampled. A sufficient amount of ground water for sampling could not be obtained from shallow well SW-2. Discussions of sampling methodology are presented in Chapter III of this report and in Appendix F.1 and ground water sampling data is summarized in Table IV-5. All of the ground water samples obtained were field tested for pH, conductivity and temperature and laboratory analyzed. The results of the field and laboratory analyses and results for detected constituents are shown in Table IV-6 and Table IV-7, respectively.

Nitrite nitrogen was the only common anion analyzed for that was not found in ADL concentrations in any of the ground water samples. Chloride, fluoride and sulfate were present in ADL concentrations in 100% of the ground water samples. The total common anion concentrations ranged from (CL5142A/1)

TABLE IV-5
GROUND WATER SAMPLING DATA

WELL #	DATE SAMPLED	DEPTH TO WATER FROM TOC	DEPTH OF WELL FROM TOC	VOLUME OF WATER IN WELL (gal)	HOURS SINCE BAILED	pH	SPECIFIC COND. UMHOS/CM	TEMP. °C	SAMPLE SENT FOR ANALYSIS
SW-1	10-29-86	7.00	19.60	2.02	5.5	12.75	2860	8	X,0
*SW-2	10-30-86	19.23	19.60	0.06	-	-	-	-	-
SW-3	10-29-86	16.03	27.01	1.76	4.0	13.35	5840	8	X
SW-4	10-29-86	8.48	17.87	1.50	4.75	11.60	5330	8	XX
SW-5	10-29-86	8.46	19.77	1.81	4.5	9.95	7480	8	XX
SW-6	10-30-86	6.76	22.01	2.44	18.75	7.15	4570	8	XX
SW-8	10-30-86	8.10	21.53	2.15	19.75	8.65	2640	8	X
SW-9	10-29-86	9.04	24.57	2.48	4.0	13.8	17620	8	X,0
DW-1	10-30-86	14.67	51.23	5.85	21.0	6.90	2120	8	XX
DW-2	10-30-86	10.16	45.15	5.60	22.25	6.65	1710	8	XX
DW-3	10-30-86	41.69	45.82	0.66	19.25	11.35	3070	8	XX
DW-4	10-30-86	13.85	49.22	5.66	17.75	6.65	4670	8	XX
MW-1	10-30-86	13.43	32.00	2.97	23.0	11.4	1760	8	XX
MW-2	10-30-86	18.84	30.60	1.88	22.75	14.0	3470	8	XX
MW-3	10-30-86	13.25	31.20	2.87	6.5	10.40	2000	8	XX
MW-4	10-30-86	21.30	39.54	2.92	8.5	9.60	2240	8	XX
**COE	10-30-86	44.49	-	-	-	7.60	3230	8	-

X = Sample sent to Princeton Testing Laboratories.

0 = Sample sent to USAFOEHL.

* Well not sampled, due to a lack of water.

** COE well depth and volume unknown, due to access.

TABLE IV-6

SLA GROUND WATER SAMPLING
FIELD AND LABORATORY ANALYTICAL RESULTS

		HART IDENTIFIER														
		LABORATORY IDENTIFIER														
Parameter	Level	SW1 SN012	SW3 SN004	SW4 SN005	SW5 SN006	SW6 SN007	DW1 SN003	DW2 SN001	DW3 SN013	DW4 SN014	MW1 SN017	MW2 SN018	MW3 SN019	MW4 SN020	MW5 SN021	Units
Priority Pollutant Metals																
Beryllium	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	mg/l	
Cadmium	0.005	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	mg/l	
Chromium	0.02	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	mg/l	
Copper	0.02	0.04	0.08	0.13	0.03	0.03	0.03	0.07	ND	ND	ND	ND	0.59	ND	mg/l	
Nickel	0.01	0.06	0.14	0.15	ND	ND	ND	0.018	0.018	ND	0.011	0.02	ND	0.43	mg/l	
Lead	0.02	ND	ND	ND	0.02	ND	ND	0.15	ND	ND	ND	ND	ND	0.17	mg/l	
Zinc	0.02	0.15	0.27	0.46	0.09	0.06	0.03	0.04	0.13	0.07	0.03	0.04	0.02	1.67	0.03	
Arsenic	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	mg/l	
Silver	0.01	ND	0.01	0.01	0.02	ND	0.01	mg/l								
Antimony	0.1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	mg/l	
Selenium	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	mg/l	
Thallium	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	mg/l	
Mercury	0.001	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	mg/l	
Common Anions																
Chloride	1.0	150	130	60	50	120	10	10	30	30	60	80	60	35	mg/l	
Fluoride	0.1	0.38	1.02	1.04	1.2	0.64	0.61	0.76	0.99	0.48	0.87	0.69	0.85	0.87	mg/l	
Bromide	0.1	4.3	3.2	1.80	3.40	3.9	0.90	0.25	1.4	ND	1.5	2.1	2.8	ND	0.90	
Nitrate Nitrogen	0.1	0.15	ND	0.24	2.2	0.63	ND	ND	ND	ND	ND	0.11	ND	0.13	mg/l	
Nitrite Nitrogen	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	mg/l	
Phosphate	0.1	2.0	4.2	3.5	0.85	ND	0.15	0.12	0.9	0.18	0.14	0.15	0.19	19.2	0.14	
Sulfate	1.0	1,260	6,300	5,600	3,870	5,000	800	700	1,700	4,500	800	2,550	1,518	1,900	4,800	
Total Dissolved Solids	2.0	2,222	6,490	5,904	9,440	5,944	1,621	1,280	2,798	5,036	1,907	3,316	1,900	1,996	4,848	
Total Petroleum Hydrocarbons	0.5	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	mg/l	

Legend appears on last page of table.

TABLE IV-6 (CONTINUED)

SLA GROUND WATER SAMPLING
FIELD AND LABORATORY ANALYTICAL RESULTS

Parameter	Detection Level	HART IDENTIFIER		LABORATORY IDENTIFIER		Units									
		SW1 SN012	SW4 SN004	SW5 SN005	SW6 SN006	DW1 SN007	DW2 SN003	DW3 SN013	DW4 SN014	MW1 SN017	MW2 SN018	MW3 SN019	MW4 SN020	DW4* SN021	
Aromatic Volatile Organics	2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ug/l	
Halogenated Volatile Organics	1-20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ug/l	
Acid Extractable Priority Pollutant Organics	10-50	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ug/l	
Base/Neutral Extractable Priority Pollutant Organics	10-80	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ug/l	
pH	NA	12.75	13.35	11.60	9.95	7.15	6.90	6.65	11.35	6.65	11.4	14.0	10.40	9.60	6.65 pH units
conductivity	NA	2,860	5,840	5,330	7,480	4,570	2,120	1,710	3,070	4,670	1,760	3,470	2,000	2,240	4,670 umhos/cm
Temperature	NA	8	8	8	8	8	8	8	8	8	8	8	8	8 °C	

Legend

ND - Not Detected
 NA - Not Applicable

* - DW/SN021 is a duplicate of DW/SN014.

ND(*) - A smaller volume of water was available for analysis requiring a higher detection limit for these samples.

mg/l - milligrams per liter

ug/l - micrograms per liter

SW - Shallow Well

DW - Deep Well

SN - Sample Number

°C - Degrees Celsius

umhos/cm - Micro-mhos per centimeter

TABLE IV-7

SLA GROUND WATER SAMPLING RESULTS FOR DETECTED CONSTITUENTS

<u>Detected Constituent (mg/l)</u>	<u>Percentage of Samples Constituent Detected</u>	<u>No. of Positive Identifications/ Total No. of Samples</u>	<u>Range of Detected Concentrations (mg/l)</u>
Priority Pollutant Metals			
Copper	57	(8/14)	0.03 - 0.59
Nickel	57	(8/14)	0.011 - 0.43
Lead	21	(3/14)	0.02 - 0.17
Zinc	100	(14/14)	0.02 - 1.67
Silver	29	(4/14)	0.01 - 0.02
Common Anions			
Chloride	100	(14/14)	10 - 150
Fluoride	100	(14/14)	0.48 - 1.2
Bromide	86	(12/14)	0.25 - 4.3
Nitrate Nitrogen	43	(6/14)	0.11 - 2.2
Phosphate	93	(13/14)	0.12 - 19.2
Ortho Sulfate	100	(14/14)	700 - 6,300
Total Dissolved Solids	100	(14/14)	1,280- 9,440
Total Petroleum Hydrocarbons	7	(1/14)	0.8

Legend

mg/l - milligrams per liter

(CL5022B/4)

711 to 6,438 mg/l for individual samples. Sulfate concentrations accounted for approximately 98% of the total of the detected concentrations of common anions in ground water samples.

Of the 13 priority pollutant metals, only copper, nickel, lead, zinc and silver were found in ADL concentrations. Zinc was the only metal found in ADL concentrations in 100% of the ground water samples. Copper and nickel were found in ADL concentrations in 57% of the ground water samples and lead and silver were found in ADL concentrations in 21% and 29% of the ground water samples, respectively.

Total dissolved solids concentrations of the ground water samples varied from 1,280 to 9,440 mg/l and averaged 3,880 mg/l. Total petroleum hydrocarbons (TPH) were only detected in ADL concentrations in one ground water sample. Aromatic and halogenated volatile organic compounds and extractable priority pollutant organic compounds were not found in ADL concentrations in any of the ground water samples.

A.2 FTA Sampling Program and Results

The sampling plan for the FTA included ground water, subsurface soil and surface sediment sampling. Ground water samples were field tested for pH, conductivity and temperature. All soil, surface sediment and ground water samples were laboratory analyzed for aromatic and halogenated volatile organic compounds, total petroleum hydrocarbons and lead.

A.2.a Ground Water Results. Two monitoring wells were installed on the perimeter of the FTA. Ground water samples from these wells were field tested and laboratory analyzed. Sampling methodology is discussed in Chapter III of this report and ground water sampling data are summarized in Table IV-5. The locations of FTA monitoring wells are shown in Figure III-6. The results of field and laboratory analyses are presented in Table IV-8.

TABLE IV-8

FTA GROUND WATER SAMPLING
FIELD AND LABORATORY ANALYTICAL RESULTS

<u>Parameter</u>	<u>Detection Level</u>	<u>HART Identifier</u>			<u>Units</u>
		<u>SW-8</u> <u>SN008</u>	<u>SW-9</u> <u>SN009</u>	<u>SW-9*</u> <u>SN010</u>	
Aromatic Volatile Organics	1	ND	ND	ND	ug/l
Halogenated Volatile Organics					
1-2 dichloroethane	1	ND	ND	11	ug/l
1,1,1-trichloroethane	2	ND	ND	11	ug/l
bromodichloromethane	2	ND	ND	3	ug/l
trichloroethane	2	ND	ND	4	ug/l
tetrachloroethane	2	ND	ND	2	ug/l
All others	1-20	ND	ND	ND	ug/l
Total Petroleum Hydrocarbons	0.5	ND	0.5	ND	mg/l
Lead	0.02	ND	ND	ND	mg/l
pH	NA	8.65	13.8	13.8	pH units
Conductivity	NA	2640	1762	1762	umhos/cm
Temperature	NA	8	8	8	°C

Legend

ND - Not Detected

* - SN010 is a duplicate of SN009

NA - Not Applicable

mg/l - milligrams per liter

ug/l - micrograms per liter

Ground water sample 008 did not contain any aromatic or halogenated volatile organics compounds, total petroleum hydrocarbons or lead in ADL concentrations. Ground water sample 009 did not contain any aromatic or halogenated volatile organic compounds or lead. It did, however, contain total petroleum hydrocarbons in a concentration equal to the detection limit of 0.5 mg/l. Ground water sample 010 did not contain any aromatic volatile organic compounds, total petroleum hydrocarbons or lead. It did, however, contain five different halogenated volatile organic compounds in ADL concentrations ranging from 2 to 11 ug/l.

A.2.b Subsurface Soil Results. A test borehole was drilled in the center of the FTA to obtain subsurface soil samples for chemical analyses. Samples were collected at five-foot intervals. Sampling methodology is discussed in Chapter III of this report and Table IV-9 presents soil sampling data for this boring (TB-1). Laboratory analyses results for the subsurface soil samples are shown in Table IV-10.

Halogenated volatile organic compounds were not detected in ADL concentrations in any of the subsurface soil samples. Total petroleum hydrocarbons and lead were found in ADL concentrations in all four subsurface soil samples. Concentrations ranged from 13 to 780 mg/kg for total petroleum hydrocarbons and from 2.34 to 4.28 mg/kg for lead. Of the aromatic volatile organic compounds analyzed for, only benzene was not found in ADL concentrations in any of the FTA subsurface soil samples. Soil sample 004 contained no aromatic volatile organic compounds in ADL concentrations. The remaining three subsurface soil samples contained variable amounts of toluene, chlorobenzene, ethylbenzene, 1,2-1,3-dichlorobenzene and 1,4-dichlorobenzene. Detected concentrations of the aromatic volatile organic compounds ranged from 300 to 3,800 ug/kg. Total detected concentrations of aromatic volatile organic compounds ranged from 4,130 to 8,250 ug/kg in individual samples.

A.2.c Surface Sediment. As part of this investigation, surface sediment was sampled in the drainage ditch leading away from the FTA. The locations of the three sediment sampling sites are shown in Figure III-4. (CL5142A/1)

TABLE IV-9
SOIL SAMPLE DATA FOR TB-1 AND TB-2

BORING #	SAMPLE #	DATE SAMPLE TAKEN	DEPTH SAMPLE TAKEN (FT)	DATE OF OVA ANALYSIS	OVA ANALYSIS (PPM)	SAMPLE SENT FOR LAB ANALYSIS
TB-1	SS-2	10-22-86	5-7	10-22-86	800	X
TB-1	SS-3	10-22-86	10-12	10-22-86	90	X
TB-1	SS-4	10-22-86	15-17	10-22-86	840	X.O
TB-1	SS-5	10-22-86	20-22	10-22-86	100	X
TB-1	SS-6	10-22-86	25-27	10-22-86	80	
TB-1	SS-7	10-22-86	28-30	10-22-86	60	
TB-2	SS-1	10-24-86	0-2	10-24-86	6	
TB-2	SS-2	10-24-86	5-7	10-24-86	14	X
TB-2	SS-3	10-24-86	10-12	10-24-86	6	
TB-2	SS-4	10-24-86	15-17	10-24-86	10	
TB-2	SS-5	10-24-86	18-20	10-24-86	20	X

X = Sample sent to Princeton Testing Laboratories

O = Sample sent to USAFOEHL.

(CL5022B/4)

TABLE IV-10

FTA SUBSURFACE SOIL SAMPLING
LABORATORY ANALYTICAL RESULTS

<u>Parameter</u>	<u>Detection Level</u>	<u>HART Identifier</u>				<u>Units</u>
		TB-1, SS-2 5-7 ft. 001	TB-1, SS-3 10-12 ft. 002	TB-1, SS-4 15-17 ft. 003	TB-1, SS-5 20-22 ft. 004	
Total Petroleum Hydrocarbons	10	440	780	290	13	mg/kg
Lead	1.0	4.28	2.88	2.34	2.58	mg/kg
Halogenated Volatile Organics	40-800	ND	ND	ND	ND	ug/kg
Aromatic Volatile Organics						
Toluene	40	1100	1200	1400	ND	ug/kg
Chlorobenzene	40	1300	530	1000	ND	ug/kg
Ethylbenzene	40	1600	2100	3800	ND	ug/kg
1,3 & 1,2-Dichlorobenzene*	40	750	ND	450	ND	ug/kg
1,4 - Dichlorobenzene	40	ND	300	1600	ND	ug/kg
Benzene	40	ND	ND	ND	ND	ug/kg

Legend

ND - Not Detected
 * - Although 1,2-dichlorobenzene and 1,3-dichlorobenzene are individual compounds, the laboratory analysis performed is not capable of distinguishing between the two compounds; therefore, these compounds are presented as a single combined concentration.

mg/kg - milligram/kilogram

ug/kg - microgram/kilogram

TB - Test Boring

SS - Soil Sample

The sampling methodology is discussed in Chapter III of this report and sediment sampling data are summarized in Table IV-11. Surface sediment samples were laboratory analyzed and the results are shown in Table IV-12.

Total petroleum hydrocarbons and lead were found in ADL concentrations in all four sediment samples. The concentrations of total petroleum hydrocarbons ranged from 350 to 16,550 mg/kg and the concentrations of lead ranged from 1.33 to 12.2 mg/kg.

Halogenated volatile organic compounds were not found in ADL concentrations in any of the sediment samples. Aromatic volatile organic compounds were found in ADL concentrations in all of the surface sediment samples except sample 007. Surface sediment samples 005, 006 and 008 contained variable amounts of the following seven aromatic volatile organic compounds: benzene, toluene, chlorobenzene, ethylbenzene, 1,4-dichlorobenzene and 1,2-1,3-dichlorobenzene. Although 1,2-dichlorobenzene and 1,3-dichlorobenzene are individual compounds, the laboratory analysis performed is not capable of distinguishing between the two compounds; therefore, these compounds are presented as a single combined concentration. Total detected concentrations of aromatic volatile organic compounds in individual sediment samples range from 12,650 to 26,400 ug/kg.

A.3 EOD Sampling Program and Results

The sampling plan for the EOD consisted of laboratory analyses of subsurface soil samples for total petroleum hydrocarbons and priority pollutant metals. A single test boring (TB-2) was drilled in the center of the EOD to obtain soil samples for chemical analyses. Subsurface soil samples were collected at five-foot intervals. Sampling methodology is discussed in Chapter III of this report and soil sampling data for this borehole are shown in Table IV-9. The location of the test borehole at the EOD is shown in Figure III-3. The subsurface soil samples were laboratory analyzed and the results are shown in Table IV-13.

TABLE IV-11
SEDIMENT SAMPLING DATA

SAMPLE SITE #	SAMPLE #	DATE SAMPLE TAKEN	DEPTH (FT) SAMPLE TAKEN	DATE OF O.V.A. ANALYSIS	O.V.A. READING	SAMPLE SENT FOR LAB ANALYSIS
SD-1	S-1	10-23-86	0-0.5	10-24-86	100 PPM	
SD-1	S-2	10-23-86	0.5-1.0	10-24-86	700 PPM	X
SD-2	S-1	10-23-86	0-0.5	10-24-86	600 PPM	X
SD-2	S-2	10-23-86	0.5-1.0	10-24-86	190 PPM	X
SD-3	S-1	10-23-86	0-0.5	10-24-86	100 PPM	X
SD-3	S-2	10-23-86	0.5-1.0	10-24-86	60 PPM	

X = Sample sent to Princeton Testing Laboratories

TABLE IV-12

FTA SURFACE SEDIMENT SAMPLING
LABORATORY ANALYTICAL RESULTS

Parameter	HART Identifier Laboratory Identifier						Units	
	Detection Level	SD-1, S-2 0.5-1.0 ft.	SD-2, S-1 0-0.5 ft.	SD-3, S-1 0-0.5 ft.	SD-2, S-2 0.5-1.0 ft.	008		
		005	006	007	008			
Total Petroleum Hydrocarbons	10	10,750	16,550	350	3,230	mg/kg		
Lead	1.0	8.03	12.2	3.85	1.33	mg/kg		
Halogenated Volatile Organics	40-800	ND	ND	ND	ND	ug/kg		
Aromatic Volatile Organics								
Benzene	40	ND	200	ND	100	ug/kg		
Toluene	40	900	2,100	ND	2,050	ug/kg		
Chlorobenzene	40	3,800	2,400	ND	2,000	ug/kg		
Ethylbenzene	40	2,700	4,500	ND	4,000	ug/kg		
1,3 & 1,2-Dichlorobenzene*	40	7,000	ND	ND	ND	ug/kg		
1,4 - Dichlorobenzene	40	12,000	4,100	ND	4,500	ug/kg		

Legend

ND - Not Detected

V - Variable (detection level varies for individual compounds)

* - Although 1,2-dichlorobenzene and 1,3-dichlorobenzene are individual compounds, the laboratory analysis performed is not capable of distinguishing between the two compounds; therefore, these compounds are presented as a single combined concentration.

mg/kg - milligrams per kilogram

ug/kg - micrograms per kilogram

SD - Sediment

S - Sample

(CL5022B/4)

TABLE IV-13

EOD SUBSURFACE SOIL SAMPLING
LABORATORY ANALYTICAL RESULTS

<u>Parameter</u>	<u>Detection Level</u>	<u>HART Identifier</u>				<u>Units</u>
		<u>TB-2, SS-2 5-17 ft. 009</u>	<u>TB-2, SS-5 18-20 ft. 010</u>	<u>TB-2, SS-5* 18-20 ft. 011</u>	<u>mg/kg</u>	
Total Petroleum Hydrocarbons	10	ND	ND	ND	ND	mg/kg
Priority Pollutant Metals						mg/kg
Beryllium	2.5	ND	ND	ND	ND	mg/kg
Cadmium	0.5	0.86	ND	ND	1.73	mg/kg
Chromium	1.0	1.53	1.39	1.46	1.46	mg/kg
Copper	1.0	13.1	12.8	12.7	mg/kg	mg/kg
Nickel	2.0	12.4	10.3	11.5	mg/kg	mg/kg
Lead	2.0	11.5	5.03	3.93	mg/kg	mg/kg
Zinc	0.5	47.6	60.1	59.1	mg/kg	mg/kg
Arsenic	0.5	ND	ND	ND	mg/kg	mg/kg
Silver	0.5	1.85	1.43	0.58	mg/kg	mg/kg
Antimony	10.0	ND	ND	ND	mg/kg	mg/kg
Selenium	0.5	ND	ND	ND	mg/kg	mg/kg
Thallium	5.0	ND	ND	ND	mg/kg	mg/kg
Mercury	0.10	ND	ND	ND	mg/kg	mg/kg

Legend

ND - Not Detected
 * - Sample 011 is a duplicate of Sample 010
 mg/kg - milligrams per kilogram
 TB - Test Boring
 SS - Soil Sample
 (CL5022B/4)

Total petroleum hydrocarbons were not found in ADL concentrations in any of the subsurface soil samples. Of the 13 priority pollutant metals analyzed for, beryllium, antimony, arsenic, selenium, thallium and mercury were not detected in ADL concentrations in any of the subsurface soil samples. Chromium, copper, nickel, lead, zinc and silver were detected in all of the subsurface soil samples and cadmium was detected in two of the three subsurface soil samples.

B. Comparison of Detection Limits with Pertinent Criteria

A comparison of the results of sample analyses with pertinent criteria is to some extent dependent upon the detection limits attained by the analytical laboratory. In order to determine if a constituent is present in a concentration which exceeds an established criteria, the detection limit reached in the analysis must be lower than the established criteria.

B.1 Comparison of Detection Limits

Method Detection Limits (MDLs) for the various analyses are either set in the SOW or specified by the applicable EPA or Standard Method. In many cases, detection limits attained by PTL (PTLMDLs) are equal to or lower than the detection limits specified in the SOW (SOWMDLs). However, for several parameters the PTLMDLs exceed the SOWMDL values. An appreciation of the significance of the differences between PTL's and the SOW's MDLs requires an understanding of what method detection limits represent.

USEPA 49 FR 43250 defines a MDL as "the minimum concentration of a substance that can be measured and reported with 99% confidence that the value is above zero." The MDL reported within EPA Method descriptions were determined empirically by analyzing reagent water spiked with various concentrations of a particular substance. As such, these MDLs are ideal low-end values and are rarely obtained in practice. "The MDLs actually achieved in a given analysis will vary depending on instrument sensitivity and matrix effects" (USEPA, 49 FR 43250).

In recognition of the various interferences that can effect practical laboratory detection limits, USEPA establishes more realistic detection limit requirements in the USEPA document SW846: "Test Methods for Evaluating Solid Wastes" (September, 1986). SW846 describes numerous analytical methods for evaluating solid wastes. These descriptions are accompanied by MDLs and Practical Quantitation Limits (PQLs). A PQL is defined as "the lowest level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions" (USEPA, September, 1986). For volatile (aromatic and halogenated) and semi-volatile (base/neutral and acid) organic compounds in water, the PQL is commonly ten times the MDL. For volatile organic compounds at low concentrations in soils, the PQL is also ten times the MDL. The PQL for volatile organic compounds at high concentrations in soils is 1,250 times the MDL. The effects of matrix interferences is at a maximum for semi-volatile organic compounds at high concentrations in soils where the PQLs are set at 10,000 times the MDL. Furthermore, USEPA states that "PQLs are highly matrix-dependent. The PQLs ... are provided for guidance and may not always be achievable" (USEPA, September, 1986).

USEPA Contract Laboratory Program (EPA/CLP) provides a comprehensive set of guidelines for producing analytical results that are accurate and defensible in a court of law. EPA/CLP establishes Contract Required Detection Limits (CRDLs) that a laboratory participating in the program must meet (USEPA, July 1987). In recognition of matrix effects associated with water samples, the CRDLs are substantially higher than the MDLs for most parameters analyzed.

The SOWMDLs, PTLMDLs and various related quantitation limits are summarized in Appendix F.2 (Tables F.2.2 to F.2.11), according to parameter analyzed and sample matrix.

PTL reported a detection limit of 1 ug/l for analysis of aromatic volatile organic compounds in water (Table F.2.2 in Appendix F.2). These PTLMDLs exceed the MDLs referred to in the SOW for all seven compounds. However, the PTLMDL values are lower than PQL and CRDL criteria. The MDLs (CL5142A/1)

specified in the SOW for halogenated volatile organic compounds are lower than those attained by PTL (Table F.2.3 in Appendix F.2). For 19 of 25 halogenated VOCs, the PTLMQLs also exceed the corresponding PQLs. With the exception of chloromethane, bromoform and 1,1,2,2-tetrachloroethane, PTLMQLs for halogenated VOC analyses were below the corresponding CRDLs.

The PTLMQLs for analyses for aromatic and halogenated VOCs in soil and sediment samples are shown in Tables F.2.4 and F.2.5 in Appendix F.2. For these analyses, the PTLMQLs exceeded the MDL, the PQL for low level soils and the CRDL for low level soils. Comparison with PQL values for high level soils indicates the PTLMQLs are generally lower. The PTLMQL of 40 ug/kg for all aromatic volatile organic analyses is significantly less than the PQL for high level soils, which range from 250 to 500 ug/kg. The PTLMQL for analysis for halogenated organic compounds was below high level soil PQL values for 13 of the 21 compounds for which a PQL is designated.

The PTLMQLs for acid and base/neutral extractable organic compounds in water exceeded the MDLs for 50 out of 51 of the compounds for which a MDL is specified, as shown in Table 4.2.6 in Appendix F.2. The PTLMQLs for B/NAE organic compounds were lower than the PQL for 49 of the 52 compounds for which PQLs are specified. The PTLMQLs for B/NAE organic compounds were equal to the CRDLs for all 49 compounds for which CRDLs are specified.

Table F.2.7 in Appendix F.2 presents the MDLs calculated by PTL in analyses for priority pollutant metals in water samples. The PTLMQLs exceeded those set in the SOW for all metals except nickel, lead and thallium. The PTLMQLs exceed the corresponding CRDL for six of the thirteen metals analyzed.

Table F.2.8 in Appendix F.2 presents the MDLs used by PTL in analyses for priority pollutant metals in soil and sediment samples. The PTLMQLs exceed the SOWMDLs for 10 of the 13 metals analyzed. The PTLMQL was equal to the SOWMDL for mercury and lower than the SOWMDL for lead and silver.

In the analysis of water samples for TPH, PTL attained a MDL of 0.5 mg/l for all but 3 samples analyzed (Table F.2.9 in Appendix F.2). The higher detection limits associated with analysis of water samples 011, 013 and 020 were the result of small sample volumes provided for analysis. The SOWMDL for TPH in water samples is 1 mg/l. PTL met the SOWMDL criteria for TPH analysis of all water samples except 013 and 020.

The MDL used by PTL in analysis of TPH in soil and sediment samples was consistently 10 mg/kg. The MDL specified in the SOW for analysis of TPH in soil and sediment samples is 1 mg/kg. The higher MDL attained by PTL in comparison to the SOWMDL is only considered significant with respect to samples 009, 010 and 011, as these samples are the only soil/sediment samples which had non-detect results.

A MDL of 0.1 mg/l was specified in the SOW for common anion analyses of water samples and a MDL of 10 mg/l was specified in the SOW for TDS analysis of water samples (Table F.2.11 in Appendix F.2). PTL was able to meet these criteria for the TDS analysis and for 5 of 7 common anions analyzed. PTLMDL attained a MDL of 1.0 mg/l for chloride and sulfate analyses as opposed to the SOWMDL of 0.1 mg/l. The higher detection limit reached by PTL in analysis of chloride and sulfate is not considered significant as all water samples analyzed contained sulfate and chloride at concentrations above PTLMDLs.

B.2 Detection Limits Compared with Pertinent Criteria

This section presents a comparison of PTL's detection limits with pertinent water quality criteria. The PTL detection limits compared with available water quality criteria for aromatic and halogenated volatile organic compounds are shown Table F.2.21 in Appendix F.2. A comparison of these values indicates that the detection limits were sufficiently low for all but the following four criteria: 1) EPA Ambient Water Quality Criteria corresponding to an incremental increase in lifetime cancer risk of 10^{-6} ; 2) EPA Ambient Water Quality Criteria for total halomethanes corresponding to an incremental increase in lifetime cancer risk of 10^{-6} ; 3) Recommended Maximum Contaminant Levels (RMCL) set at zero for four (CL5142A/1)

halogenated volatile organic compounds; and (4) a proposed maximum contaminant level (MCL) for vinyl chloride. The EPA Ambient Water Quality Criteria which correspond to an increase in cancer risk are estimates presented for information purposes only and do not represent an EPA judgment on an acceptable risk level; thus, it is not considered significant that detection limits for certain compounds are not below these standards. PTL detection limits for vinyl chloride, 1,2-dichloroethane, carbon tetrachloride and trichloroethylene are above the RMCLs of zero for these compounds. PTL detection limits for vinyl chloride are also above the proposed MCL for vinyl chloride.

Table F.2.22 in Appendix F.2 shows the PTL detection limits and the available water quality criteria for acid and base/neutral extractable priority pollutant organic compounds. A comparison of these values indicates that the detection limits were sufficiently low for all but the following three criteria: 1) EPA Ambient Water Quality Criteria for polynuclear aromatic hydrocarbons corresponding to an incremental increase in lifetime cancer risk of 10^{-6} ; 2) EPA Ambient Water Quality Criteria corresponding to an incremental increase in lifetime cancer risk of 10^{-6} ; and 3) EPA Ambient Water Quality Criteria based upon organoleptic data. As with the volatile organic compounds, EPA Ambient Water Quality Criteria corresponding to an increase in cancer risk are presented by EPA for information purposes only and, thus, it is not considered significant that detection limits for certain compounds are not below these standards. The detection limits that do not conform to EPA Ambient Water Quality Criteria based on organoleptic data are considered to be insignificant for this investigation as no adverse health effects are known to occur at or below the detection limits used by PTL.

Table F.2.23 in Appendix F.2 presents the PTL detection limits and available water quality criteria for priority pollutant metals, common anions, total dissolved solids and TPH. A comparison of these values indicates that detection limits were sufficiently low for all constituents except beryllium, mercury and arsenic. The detection limits for beryllium and arsenic are above the EPA Ambient Water Quality Criteria corresponding to an incremental increase in lifetime cancer risk of 10^{-6} ; however, this (CL5142A/1)

criteria is presented for information purposes only and does not represent EPA judgement and, given the amount of sample provided, a detection limit as low as this criteria was unattainable using current laboratory methodologies. The detection limit for mercury is above the EPA Ambient Water Quality Criteria based on human health effects; however, the detection limit used by PTL was below the Safe Drinking Water Act MCL of 0.002 mg/l as established by USEPA.

C. Evaluation of Laboratory QC Data and Reliability of Analytical Results

Sample results submitted by PTL to HART were accompanied by various types of QC data. An evaluation of this data provides the means to assess the precision of laboratory procedures and the accuracy of the analytical results. Specific procedures for evaluating QC data are not specified in the MAFB IRP Phase II SOW. Thus, EPA/Contract Laboratory Program (CLP) guidelines were used, where applicable, to determine the quality of analytical results generated by PTL. These procedures are outlined in "Laboratory Data Validation--Functional Guidelines For Evaluating Organic Analyses" and "Laboratory Data Validation--Functional Guidelines For Evaluating Inorganic Analyses" (EPA, 1987).

C.1 Volatile Organic Compounds

Analyses for aromatic and halogenated volatile organic compounds (VOCs) in water samples were performed by PTL by using procedures outlined in EPA Method 601 (Purgeable Halocarbons) and EPA Method 602 (Purgeable Aromatics). A complete enumeration of the procedures which comprise EPA Method 601 and 602 can be found in "Methods For Organic Chemical Analysis Of Municipal And Industrial Wastewater:" 49 FR 43250, October 26, 1984. The results of aromatic and halogenated VOC analyses of water samples can be found as Appendix H.1.

All water samples were analyzed for VOCs within the 14 day holding time specified in Methods 601 and 602. Table F.2.12 in Appendix F.2 provides a chronology for water samples from the date of collection until VOC analyses.

Soil and sediment samples were analyzed for VOCs according to EPA Method 8010 (Halogenated Volatile Organics) and EPA Method 8020 (Aromatic Volatile Organics). A complete enumeration of the procedures which comprise EPA Methods 8010 and 8020 can be found in EPA's "Test Methods For Evaluating Solid Wastes," September, 1986.

Analysis of soil and sediment samples for VOCs was performed within the 14 day holding time specified in Methods 8010 and 8020. Table F.2.13 in Appendix F.2 provides a chronology for soil and sediment samples from the date of collection until VOC analyses.

Water samples collected on 10/29/86 for VOC analyses included ground water samples from five wells (sample numbers 004, 005, 006, 009 and 012), one duplicate ground water sample (sample number 010), one trip blank sample and two equipment blank samples (sample numbers 011 and 015). These samples were grouped by PTL as Job No. 86GW3506. Volatile organic compounds were not detected in the trip blank nor the equipment blank samples in concentrations above the MDLs. This indicates proper decontamination of sampling equipment and that no inadvertent contamination of this group of samples occurred from either improper laboratory sample bottle preparation or sample shipment.

Water samples collected on 10/30/86 included ground water samples from twelve wells (sample numbers 001, 003, 007, 008, 013, 014, 017, 018, 019, 020, 021 and 022) and a trip blank sample. These samples were grouped by PTL as Job No. 86GW3523. Volatile organic compounds were not detected in the trip blank sample in concentrations above the MDLs. This indicates that no inadvertent contamination of this group of samples occurred from either improper laboratory sample bottle preparation or sample shipment. The procedures used for decontamination of the sampling equipment used for the collection of the ground water samples in PTL Job No. 86GW3523 were (CL5142A/1)

identical to those employed for the decontamination of equipment used to collect PTL Job No. 86GW3506 ground water samples. Therefore, the results of analysis of 86GW3506 equipment blank samples (sample numbers 011 and 015) are applicable to 86GW3523 ground water sample analyses. As analyses of equipment blank samples 011 and 015 produced non-detect results for aromatic and halogenated VOCs, proper sampling equipment decontamination is inferred for 86GW3523 ground water samples.

Four surface water samples (sample numbers 023, 024, 025 and 026) and one duplicate surface water sample (sample number 027) were collected on 11/2/86. With the exception of the duplicate sample, all of the samples were submitted to PTL for analysis for aromatic and halogenated VOCs. These samples were grouped by PTL as Job No. 86GW3538. As no trip blank sample accompanied this group of samples, it is difficult to assess the potential for inadvertent contamination of these samples from either improper sample bottle preparation or sample shipment. Surface water samples were collected in sample bottles provided by ICHEM Inc., as were all water, soil and sediment sample bottles. Assuming ICHEM Inc. prepared all sample bottles for VOC analyses in the same manner, trip blank results for PTL Job Nos. 86GW3506 and 86GW3523 water samples should be applicable to PTL Job No. 86GW3538 water samples. Both of these sample group trip blanks produced non-detect results, indicating that inadvertent contamination of water samples from improper sample bottle preparation did not occur. Surface water samples were obtained as grab water samples directly in laboratory prepared sample bottles. Thus, equipment blank criteria are not applicable to surface water samples.

As shown on Table F.2.12 in Appendix F.2, all aromatic and halogenated VOC analyses of water samples were conducted in a 4-day period beginning November 10, 1986 and ending November 13, 1986. Analyses dates were derived from both analytical results reports (Appendix H.1) and laboratory chronicles (Appendix H.9.d).

Laboratory QC documentation of VOC analyses of water samples includes a matrix spike analyses of sample 026. This sample was spiked with 340 ug/l of bromodichloromethane. Upon analysis, this sample was determined (CL5142A/1)

to contain bromodichloromethane at a concentration of 345 ug/l, for a percent recovery of 101.4 percent (see Appendix H.9.c). No acceptable recovery ranges for this compound are specified in EPA/CLP guidelines or in the SOW. However, acceptable criteria are specified for several other compounds as shown in Table IV-14. While bromodichloromethane is not included in this table, the 101.4 percent recovery of this spike is well within the strictest criteria listed. Likewise, matrix spike analyses for bromodichloromethane and three other VOC's performed on Sample 023 produced recoveries near 100 percent (Appendix H.9.C). Acceptable ranges for these compounds are not provided by EPA/CLP. However, the recoveries all fall well within the strictest ranges specified in Table IV-14. These matrix spike analyses results support the validity of VOC analyses results for water samples.

PTL conducted duplicate analyses on ground water sample 010 and surface water sample 024 (Appendix H.9.C). The four compounds analyzed in duplicate in sample 024 were not present at concentrations above PTLMQLs. This precluded calculation of relative percent difference (RPD) values. Of the five VOC's analyzed in duplicate for sample 010, four produced RPD values of zero and the fifth produced an RPD of 9.5. While EPA/CLP does not provide acceptable ranges for RPD values from duplicate VOC analyses, these RPD results indicate the accuracy of laboratory analytical procedures.

The QC data discussed above can be used to assess the validity and accuracy of VOC results for water samples collected at MAFB. All analyses were performed within the recommended holding times. Trip and equipment blank results indicate that sampling equipment was properly decontaminated and inadvertent contamination of water samples did not occur. The available laboratory QC data does suggest that proper analytical methodologies were employed for VOC analyses. However, in the absence of more extensive QC documentation, particularly surrogate recovery data and additional matrix spike analyses, the accuracy of results for VOC analyses of water samples cannot be fully evaluated. Therefore, all positive results and MDL's for non-detect results should be regarded as estimated values.

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TABLE IV-14

EPA/CLP MATRIX SPIKE RECOVERY
LIMITS FOR VOLATILE ORGANIC
COMPOUNDS

<u>Matrix Spike Compound</u>	<u>Acceptable Recovery Range (Percent)</u>
1,1-Dichloroethene	61-145
Trichloroethene	71-120
Chlorobenzene	75-130
Toluene	76-125
Benzene	76-127

From: USEPA Contract Laboratory Program, Statement
of Work for Organics Analysis, July 1987.

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Four sediment samples (sample numbers 005, 006, 007 and 008), four soil samples (sample numbers 001, 002, 003 and 004), and a trip blank sample were submitted to PTL for VOC analyses. These samples were grouped by PTL as Job No. 86GW3440. Volatile organic compounds were not detected in the trip blank sample in concentrations above the MDL. This indicates that no inadvertent contamination of this group of samples occurred from either improper sample bottle preparation or sample shipment. As no equipment blank accompanied the soil and sediment samples sent for VOC analyses, the potential for cross-contamination or inadvertent contamination of soil and sediment samples via improperly decontaminated sampling equipment cannot be assessed.

As shown on Table F.2.13 in Appendix F.2, all aromatic and halogenated VOC analyses of soil and sediment samples were conducted in a 3-day period beginning November 3, 1986 and ending November 5, 1986. Analyses dates were derived from both analytical results reports (Appendix H.2) and laboratory cronicles (Appendix H.9.d).

No halogenated organic compounds were identified above the MDL's in any of the soil samples analyzed. Six aromatic compounds were identified quantitatively and, in accordance with the SOW, confirmatory analyses were run on samples 002, 003, 005 and 007 (Appendix H.2). The presence of all compounds identified in these samples during the initial analyses were confirmed upon reanalysis. In addition, benzene was not detected in sample 005 originally, but was quantified at 1000 ug/kg upon reanalysis.

The QC data discussed above can be used to assess the validity of VOC analytical results for soil and sediment samples. Holding time criteria were met and trip blank results indicate no occurrence of inadvertent sample contamination. Results of confirmatory analyses verified the presence of the aromatic VOCs detected in soil and sediment samples. However, the lack of laboratory blank, surrogate recovery and matrix spike analyses data suggests that, in spite of the favorable data that does exist, VOC results for soil and sediment samples can only be regarded as estimated values.

C.2 Base/Neutral And Acid Extractable Compounds

As per the MAFB IRP Phase II SOW, analyses for base/neutral and acid extractable (B/NAE) organic compounds in water samples were conducted by PTL in accordance with procedures in EPA Method 625 (Base/Neutrals and Acids). Soil and sediment samples were not analyzed for these semi-volatile organic compounds. A complete enumeration of the procedures which comprise EPA Method 625 can be found in "Methods For Organic Chemical Analysis Of Municipal And Industrial Wastewater:" 49 FR 43250, October 26, 1984. The results of B/NAE organic analyses of water samples can be found as Appendix H.3.

The holding time from sample collection to extraction specified in EPA Method 625 is 7 days. Water samples 004, 005, 006, 012 and 015 were extracted 13 days following collection. All other water samples were extracted within the 7-day holding time. All water samples were completely analyzed within the 40-day holding time from sample collection to analyses specified in EPA Method 625. Table F.2.14 in Appendix F.2 provides a chronology for water samples from the date of collection until extraction and B/NAE organic analyses.

Surrogate recovery data were included with the results of B/NAE analyses by PTL to document laboratory QC procedures. Analyses of surrogates was performed for the base/neutral fraction of the analyses and not the acid fraction. In the absence of surrogate recovery data for the acid fraction, the validity of acid results was determined using base/neutral surrogate recovery data. No standards of performance for surrogate recoveries is specified in the SOW or by PTL. In this review, criteria specified in EPA/CLP are used for comparison with surrogate recovery results. These criteria are summarized in Table IV-15. According to EPA/CLP procedures, if two or more of the surrogate recovery results for a sample fall outside the acceptable range for that compound, associated positive results and the MDL for non-detect results are flagged (CL5142A/1)

TABLE IV-15

EPA/CLP SURROGATE
SPIKE RECOVERY LIMITS FOR THE ANALYSIS OF
BASE/NEUTRAL EXTRACTABLE ORGANIC COMPOUNDS IN WATER

<u>Surrogate Compound</u>	<u>Acceptable Percent Recovery</u>
d5-nitrobenzene	35-114
2-fluorobiphenyl	43-116
d5-phenol	10-94
2-fluorophenol	21-100
2,4,6-tribromophenol	10-123

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as estimated values. In addition, if any surrogate recovery result is less than 10 percent, EPA/CLP protocol requires all associated positive results be flagged as estimated and all non-detect results be flagged as unusable.

Table F.2.25 in Appendix F.2 summarizes surrogate recovery results for PTL Job No. 86GW3506 water samples which were analyzed for B/NAE organic compounds (sample numbers 004, 005, 006, 012 and 015). These samples were collected on 10/29/86. Of the 10/29/86 water samples, 006 and 012 had two surrogate recoveries fall outside the EPA/CLP acceptable ranges and sample 015 had three surrogate recoveries fall outside the acceptable ranges. However, none of the surrogate recovery results for 10/29/86 samples were less than 10 percent and, therefore, the MDLs for 10/29/86 samples, including 006, 012 and 015, are still usable as estimated values, as these samples all had non-detect results for B/NAE organic analyses.

Table F.2.26 in Appendix F.2 summarizes surrogate recovery results for PTL Job No. 86GW3523 water samples which were analyzed for B/NAE organic compounds (sample numbers 001, 003, 007, 013, 014, 017, 018, 019, 020, 021 and a method blank). These samples were collected on 10/30/86. Of the 10/30/86 samples, seven samples (sample numbers 001, 003, 007, 013, 019, 020 and the method blank) had two or more surrogate recovery results fall outside the EPA/CLP acceptable ranges. Of these seven samples, none had surrogate recovery results of less than 10 percent and, therefore, the MDLs for analysis of these samples are usable as estimated values, as these samples all had non-detect results for B/NAE organic analyses. The remainder of the 10/30/86 water samples had only one surrogate recovery result fall outside the EPA/CLP acceptable range and had no surrogate recovery results of less than 10 percent. Thus, the MDLs for the remainder of the 10/30/86 samples are usable as accurate values, as those samples all had non-detect results for B/NAE organic analyses.

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Table F.2.24 in Appendix F.2 summarizes surrogate recovery results for PTL Job No. 86GW3538 water samples which were analyzed for B/NAE organic compounds (sample numbers 023, 024, 025, 026 and 027). These samples were collected on 11/2/86. Of the 11/2/86 samples, samples 023 and 024 had only one surrogate recovery each that fell outside the EPA/CLP acceptable ranges and had no surrogate recovery results of less than 10 percent. According to EPA/CLP, the MDLs for these samples are judged to be accurate, as these samples had non-detect results for B/NAE organic analyses. Samples 025, 026 and 027 had two, four and three surrogate recoveries, respectively, fall outside the EPA/CLP acceptable ranges. No surrogate recovery results for samples 025, 026 and 027 were less than 10 percent. Therefore, the MDLs reported for these three samples should be regarded as estimates, as these samples all had non-detect results for B/NAE organic analyses.

No equipment blank accompanied samples in PTL Job No. 86GW3523. These samples were collected using identical equipment and decontamination procedures employed to collect samples in PTL Job No. 86GW3506. Therefore, the results for the equipment blank in 86GW3506 can be applied to results from the 86GW3523 group of samples. Analysis of this equipment blank detected no B/NAE compounds above PTLMDL. Therefore, the possibility of cross-contamination or inadvertent contamination of the samples during collection can be eliminated. No equipment blank accompanied the surface water samples (PTL Job No. 86GW3538). As surface water samples are grab samples and no sampling equipment was required to collect these samples, an equipment blank was not required.

The available field and laboratory QC data allow the following judgments to be made regarding the validity of B/NAE results for water samples collected at MAFB. Extraction of samples in Job No. 86GW3506 exceeded 7 days but occurred within 14 days. This renders all associated results as estimated values. All other extraction and analysis holding

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time criteria were met. Analysis of equipment blanks indicates that sample preparation and collection were performed properly. Based on surrogate recovery data, EPA/CLP guidelines dictate that MDL's for samples 001, 003, 006, 007, 012, 013, 015, 019, 020, 025, 026 and 027 be regarded as estimated values. Favorable surrogate recovery results indicate that MDL's for samples 014, 017, 018, 023 and 024 are accurate.

C.3 Total Petroleum Hydrocarbons

Analysis for TPH in water samples was performed by PTL by using procedures outlined in EPA Method 418.1 (Total Recoverable Petroleum Hydrocarbons). A complete enumeration of the procedures which comprise EPA Method 418.1 can be found in "Methods for Chemical Analysis of Water and Wastes:" EPA-600/4-79-020, March 1983. The results of TPH analysis of water samples can be found as Appendix H.4.

Table F.2.17 in Appendix F.2 provides a chronology for water samples from the date of collection until TPH analysis. Holding times from the collection of water samples to analysis are not specified in EPA Method 418.1 or in the MAFB IRP Phase II SOW.

A total of 25 water samples were submitted to PTL for TPH analysis. These included the following: (1) PTL Job No. 86GW3506 sample numbers 004, 005, 006, 009, 010, 011, 012 and 015, collected on 10/29/86; (2) PTL Job No. 86GW3523 sample numbers 001, 003, 007, 008, 013, 014, 017, 018, 019, 020, 021 and 022, collected on 10/30/86; and (3) PTL Job No. 86GW3538 sample numbers 023, 024, 025, 026 and 027, collected on 11/2/86.

The water samples for TPH analysis that were collected on 10/29/86 were accompanied by a duplicate sample and two equipment blank samples. Petroleum hydrocarbons were not detected in either equipment blank sample in concentrations above the MDL of 0.5 mg/l. This indicates that proper decontamination procedures were employed for field sampling equipment.

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The sample from well SW-9 (sample number 009) was determined to contain TPH at the detection limit of 0.5 mg/l. The duplicate sample from this well (sample number 010) was not found to contain TPH at concentrations above the MDL of 0.5 mg/l. Because TPH was detected in 009 at the minimum quantifiable level, it is difficult to draw any conclusions based on the discrepancy between the results for 009 and 010.

The water samples collected on 11/2/86 for TPH analysis included duplicate samples (sample numbers 023 and 027). Neither sample was found to contain TPH in concentrations above the MDL of 0.5 mg/l.

PTL reported that the small sample volumes provided to the laboratory for TPH analysis precluded duplicate analyses of samples. No matrix spike recovery data or any other QC documentation accompanied the results of TPH analysis of water samples. Although there is no evidence suggesting that TPH results are inaccurate, the lack of QC documentation requires that positive results and the MDLs for non-detect results for water samples be regarded as estimated values.

TPH analysis was performed on all soil and sediment samples submitted to PTL. Following extraction, sample extracts were analyzed by PTL by using procedures outlined in EPA Method 418.1. The results of TPH analysis of soil and sediment samples can be found in Appendix H.5.

Table F.2.18 provides a chronology for soil and sediment samples from date of collection until TPH analysis. Holding times from the collection of soil and sediment samples to analysis are not specified in EPA Method 418.1 or in the MAFB IRP Phase II SOW.

The eleven soil and sediment samples submitted to PTL for TPH analysis were grouped as PTL Job Nos. 86GW3440 and 86GW3441. These groups included sample numbers 001, 002, 003, 004, 005, 006, 007 and 008 (86GW3440) and 009 and 010 (86GW3441). Also included in 86GW3441 was sample 011, a duplicate of subsurface soil sample 010.

TPH was not detected in concentrations above the MDL of 10.0 mg/kg in duplicate samples 010 and 011. It is difficult to assess the consistency of laboratory analytical procedures from duplicate analyses yielding non-detect results. No laboratory QC documentation accompanied TPH analysis results for soil and sediment samples. Although there is no evidence suggesting that TPH results are inaccurate, the lack of QC documentation requires that positive results and MDLs for non-detect results be regarded as estimated values.

C.4 Total Dissolved Solids

As per the MAFB IRP Phase II SOW, all water samples collected at MAFB for total dissolved solids (TDS) analysis were analyzed in accordance with the procedures outlined in EPA Method 160.1. A complete enumeration of the procedures which comprise EPA Method 160.1 can be found in "Methods for Chemical Analysis of Water and Wastes:" EPA-600/4-79-020, March 1983. The results of TDS analysis of water samples can be found as Appendix H.8.

Table F.2.20 in Appendix F.2 provides a chronology for water samples from the date of collection until TDS analysis. The USAFOEHL Sampling Guide (July, 1985) specifies a holding time for TDS analysis of water samples (EPA 160.1) of 7 days. All TDS analysis of water samples was performed within 7 days.

A total of 21 water samples were submitted to PTL for TDS analysis. These included the following: (1) PTL Job No. 86GW3506 sample numbers 004, 005, 006, 012 and 015, collected on 10/29/86; (2) PTL Job No. 86GW3523 sample numbers 001, 003, 007, 013, 014, 017, 018, 019, 020, 021 and 022, collected on 10/30/86; and (3) PTL Job No. 86GW3538 sample numbers 023, 024, 025, 026 and 027, collected on 11/2/86.

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EPA/CLP protocols maintain that samples with results 5 times greater than the contract required detection limit (PTLMDLs are used here) are accurate and precise if associated laboratory duplicate analyses yield RPD values that are within the range of \pm 20 percent (see legend in Table F.2.30 for definition of RPD). Samples with results less than 5 times the MDL are judged to be precise if duplicate results do not vary by a magnitude greater than the MDL. Duplicate TDS analyses were performed on water samples 017 and 024 and the results of duplicate analyses are included in Appendix H.9.d. Tables F.2.31 and F.2.32 summarize the results of duplicate TDS analyses of water samples. Duplicate TDS analysis of sample 017 produced results of 1,986 mg/l and 1,918 mg/l, for a RPD value of 1.15. Duplicate TDS analysis of sample 024 produced results of 2,625 mg/l and 2,567 mg/l, for an RPD value of 2.2. These duplicate results indicate that the results of TDS analyses of PTL Job No. 86GW3523 and 86GW3538 water samples are accurate.

In addition to laboratory duplicate analyses, two field duplicate samples (sample numbers 023 and 027) were included in the PTL Job No. 86GW3538 water samples. These field duplicate samples were found to contain TDS at concentrations of 4,460 mg/l and 4,761 mg/l. Although EPA/CLP RPD protocols do not necessarily apply to field duplicate samples, applying RPD criteria to field duplicate analysis results provides a means of quantitatively assessing field duplicate results. The RPD value calculated from the results of analysis of samples 023 and 027 is 6.5.

C.5 Common Anions

Analyses for common anions in water samples were performed by PTL by the EPA Methods summarized in Appendix H.9.a. A complete enumeration of the procedures which comprise these analytical methods can be found in "Methods for Chemical Analysis of Water and Wastes:" EPA-600/4-79-020, March 1983. The results of common anion analyses of water samples can be found as Appendix H.8.

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Table F.2.19 provides a chronology for water samples from the date of collection to common anion analyses. The USAFOEHL sampling guide (July, 1985) specifies a holding time of 48 hours from sample collection to nitrite and nitrate nitrogen analyses. The nitrite and nitrate nitrogen analyses were performed within the 48-hour holding time for all water samples. The USAFOEHL sampling guide specifies a 28-day holding time from sample collection to analyses for bromide, chloride, fluoride, phosphate and sulfate. All water samples were analyzed within the 28-day holding time for these common anions.

A total of 21 water samples were submitted to PTL for common anion analyses. These include the following: (1) PTL Job No. 86GW3506 sample numbers 004, 005, 006, 012 and 015, collected on 10/29/86; (2) PTL Job No. 86GW3523 sample numbers 001, 003, 007, 013, 014, 017, 018, 019, 020, 021 and 022, collected on 10/30/86; and (3) PTL Job No. 86GW3538 sample numbers 023, 024, 025, 026 and 027, collected on 11/2/86.

Duplicate and matrix spike QC analyses were performed in conjunction with common anion analyses. Tables F.2.30, F.2.31 and F.2.32 in Appendix F.2 contain the results of QC analyses for PTL 86GW3506, 86GW3523 and 86GW3538 water samples, respectively. These QC analyses results can also be found as reported by PTL in Appendix H.9.b. Sample analyses dates presented in Table F.2.19 in Appendix F.2 indicate that analyses were performed on groups of water samples defined by PTL job numbers. The following discussions summarize the QC data generated during analyses of sample groups for each common anion.

PTL 86GW3523 and 86GW3506 water samples were analyzed on 11/3/86 for bromide. A duplicate bromide analysis was performed on sample 001 and yielded values of non-detect and 0.50 mg/l. Where one or both of the analyses produces non-detect results, the RPD is not calculated. However, as the results differed by 5 times the MDL, associated bromide results or

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the MDL for non-detect results should be considered estimated. In contrast with duplicate analyses results, matrix spike analyses results support the validity of bromide results for this group of samples. A percent recovery of 93 is calculated from the matrix spike bromide analyses results for sample 001, which is well within the EPA/CLP acceptable range of 74 to 125 percent.

PTL 86GW3538 water samples were analyzed on 11/21/86 for bromide. A duplicate bromide analyses was performed on sample 025. This analysis yielded values with a calculated RPD value of 22. A RPD value of 22 falls outside the EPA/CLP acceptable range of +/- 20 percent specified for samples with results greater than 5 times the MDL. As bromide analyses results were greater than 5 times the MDL, associated bromide results should be considered estimated. Again in contrast with duplicate analyses results, matrix spike analyses results support the validity of bromide analyses results for this group of samples. A percent recovery of 80 was calculated from the matrix spike bromide analyses of sample 025, which is within the EPA/CLP acceptable range.

PTL 86GW3523 and 86GW3506 water samples were analyzed on 11/19/86 for phosphate. A duplicate phosphate analyses was performed on sample 018 and yielded values of 0.14 and 0.15 mg/l. As these values are less than 5 times the MDL and differ by a value less than the MDL, associated phosphate results should be considered accurate. A percent recovery of 93 was calculated from the matrix spike phosphate analyses results for sample 025, which is well within the EPA/CLP acceptable range. Thus, matrix spike analyses results further demonstrate the accuracy of phosphate analyses results for this group of samples.

PTL 86GW3538 water samples were analyzed on 11/21/86 for phosphate. A duplicate phosphate analyses was performed on sample 026 and yielded non-detect results for both runs. Where both of the analyses produce non-detect results, the RPD is not calculated. Therefore, duplicate (CL5142A/1)

phosphate analyses results for sample 026 cannot be used to evaluate the accuracy of phosphate analyses results for this group of samples. A percent recovery of 104 was calculated from the matrix spike phosphate analyses results for sample 026, which is well within the EPA/CLP acceptable range. Therefore, phosphate analyses results for this group of samples should be considered accurate.

PTL 86GW3523 water samples were analyzed on 10/31/86 for nitrite and nitrate nitrogen. A duplicate nitrite nitrogen analyses was performed on sample 008 and yielded non-detect results for both runs. A duplicate nitrate nitrogen analyses was performed on sample 020 and yielded non-detect results for both runs. As a RPD value cannot be calculated from the results of duplicate nitrite and nitrate nitrogen analyses, these duplicate analyses cannot be used to evaluate the accuracy of nitrite or nitrate nitrogen analyses results for this group of samples. Matrix spike analyses were performed in conjunction with nitrite and nitrate nitrogen analyses. A percent recovery of 95 is calculated from the results of the matrix spike nitrite nitrogen analyses performed on sample 008. A percent recovery of 100 is calculated from the results of matrix spike nitrate nitrogen analyses performed on sample 020. These matrix spike results are well within the EPA/CLP acceptable range and, therefore, indicate that nitrite and nitrate nitrogen analyses results for this group of samples should be considered accurate.

PTL 86GW3506 water samples were analyzed on 10/30/86 for nitrite and nitrate nitrogen. Duplicate nitrite and nitrate nitrogen analyses were performed on sample 015 and yielded non-detect results for both runs for both anions. As a RPD value cannot be calculated from duplicate nitrite and nitrate nitrogen analyses results for sample 015, these duplicate analyses cannot be used to evaluate the accuracy of nitrite and nitrate nitrogen analyses results for this group of samples. Matrix spike nitrite and nitrate analyses were performed on sample 015. Percent recoveries calculated from matrix spike analyses results are 90 (nitrite) and 112 (CL5142A/1)

(nitrate). As these results are within the EPA/CLP acceptable range, matrix spike analyses results indicate that the results of nitrite and nitrate nitrogen analyses should be considered accurate.

PTL 86GW3538 water samples were analyzed on 11/3/86 for nitrate nitrogen. A duplicate nitrate nitrogen analyses was performed on sample 027 and yielded values of 1.27 and 0.83 mg/l. The RPD value calculated from these results is 42. As this RPD value is outside the EPA/CLP acceptable range, nitrate nitrogen analyses results for this group of samples should be considered estimated. In contrast with duplicate analyses, matrix spike analyses results support the validity of nitrate nitrogen analysis results for this group of samples. A percent recovery of 90 was calculated from the matrix spike nitrate nitrogen analyses results for sample 027, which is within the EPA/CLP acceptable range.

PTL 86GW3538 water samples were analyzed on 11/4/86 for nitrite nitrogen. No duplicate or matrix spike analyses were performed on a sample in this group. Thus, the accuracy of nitrate nitrogen analyses results cannot be assessed for this group of samples and the results or MDLs for non-detect results should be considered estimates.

All water samples were analyzed on 11/4/86 for chloride. Duplicate chloride analyses were performed on samples 005 and 021. The RPD values calculated from the results of duplicate analyses of samples 005 and 021 are 6.67 and 0, respectively. As the results of chloride analyses for both samples were greater than five time the MDL, the EPA/CLP acceptable range of +/- 20 percent is used for RPD comparison. This comparison indicates that chloride analyses results for all water samples should be considered accurate. No matrix spike chloride analyses were performed on water samples and, therefore, no additional data is available to evaluate the accuracy of chloride analyses results for water samples.

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All water samples were analyzed on 11/19/86 for fluoride. Duplicate fluoride analyses were performed on samples 008 and 026. The RPD values calculated from the results of duplicate analyses for samples 008 and 026 are 5.9 and 0, respectively. As the results for duplicate fluoride analyses for both samples were greater than 5 times the MDL, the EPA/CLP acceptable range of +/- 20 percent is used for comparison of RPD values. This comparison indicates that fluoride analyses results for all water samples should be considered accurate. Matrix spike fluoride analyses were also performed on samples 008 and 026. The percent recoveries calculated from the results of these matrix spike analyses are 88 (sample 008) and 90 (sample 026). As these percent recoveries fall within the EPA/CLP acceptable range, matrix spike analyses provide further support of the accuracy of fluoride analyses results for all water samples.

All water samples were analyzed on 11/20/86 for sulfate. Duplicate sulfate analyses were performed on samples 008 and 026. The RPD values calculated from the results of duplicate analyses for samples 008 and 026 are 3.0 and 10.1, respectively. As the results for duplicate sulfate analyses were greater than 5 time the MDL, the EPA/CLP acceptable range of +/- 20 percent is used for comparison of RPD values. This comparison indicates that sulfate analyses results for all water samples should be considered accurate. Matrix spike sulfate analyses were also conducted on samples 008 and 026. The percent recoveries calculated from the results of these matrix spike analyses are 117 (sample 008) and 100 (sample 026). As these percent recovery results fall within the EPA/CLP acceptable range, matrix spike analyses provide further support of the accuracy of sulfate analyses results for water samples.

C.6 Metals

Analyses for priority pollutant metals in water samples were performed by PTL by the EPA Methods summarized in Appendix H.9.a. A complete enumeration of the procedures which comprise the analytical methods can be (CL5142A/1)

found in "Methods for Chemical Analysis of Water and Wastes:" EPA-600/4-79-020, March 1983. The results of priority pollutant metals analyses for water samples can be found in Appendix H.6.

Table F.2.15 in Appendix F.2 provides a chronology for water samples from the date of collection until priority pollutant metals analyses. The USAFOEHL sampling guide (July, 1985) specifies a holding time for sample collection to total mercury analysis of 28 days and a holding time for sample collection to analysis for all other priority pollutant metals of 6 months. All water samples were analyzed for 13 priority pollutant metals or lead within the holding time specified by USAFOEHL.

A total of 25 water samples were submitted to PTL for priority pollutant metals analyses. These include the following: PTL Job No. 86GW3506 sample numbers 004, 005, 006, 009, 010, 011, 012 and 015, collected on 10/29/86; PTL Job No. 86GW3523 sample numbers 001, 003, 007, 008, 013, 014, 017, 018, 019, 020, 021 and 022, collected on 10/30/86; and PTL Job No. 86GW3538 sample numbers 023, 024, 025, 026 and 027, collected on 11/2/86. Tables F.2.27, F.2.28 and F.2.29 summarize the results of duplicate and matrix spike analyses performed in conjunction with priority pollutant metals analyses of the 86GW3506, 86GW3523 and 86GW3538 sample groups.

All water samples were analyzed for metals as a group. Therefore, any QC data generated during these analyses should apply to all water sample results.

Duplicate analyses were performed for all metals analyzed with the exception of antimony. All results for antimony are judged to be estimated values in the absence of QC documentation. No RPD values could be calculated for beryllium, cadmium, chromium, arsenic, selenium, thallium and mercury as duplicate analyses produced non-detect results.
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Three duplicate samples analyzed for copper (006, 007, and 027) yielded results less than 5 times the MDL and exhibited a variance of less than the MDL, indicating accurate copper results. Only one duplicate analysis for nickel (027) yielded results above the MDL of 0.01 mg/l. These results were less than 0.05 mg/l and varied by only 0.001 mg/l. Therefore, all associated nickel results should be considered accurate. Likewise, duplicate analyses of lead in sample 006 yielded results less than 5 times the MDL (0.02 mg/l), but varied by only 0.001 mg/l. As such, all associated results for lead are considered to be accurate. Three duplicate analyses were conducted for zinc. Two samples (006 and 007) produced results less than 5 times the MDL (0.02 mg/l), but with a variation of less than the MDL. The third sample (027) produced results which were greater than 5 times the MDL and had a RPD value of 26. Although the available QC data indicates that zinc results less than 0.10 mg/l (5 x MDL) are supported by QC data that conform to EPA/CLP criteria as accurate, in light of the duplicate results for sample 027 all zinc results are considered estimated values. Finally, duplicate analyses for silver were performed on sample 006. The results were less than 5 times the MDL, but with a variance of less than the MDL. Based on these data, silver results for water samples are considered to be accurate.

Spike recovery analyses were performed for all metals except antimony. Percent recoveries ranged between 86 and 111 percent. As these percent recoveries are all within the EPA/CLP acceptable range of 75 to 125 percent, matrix spike analyses results support the validity of priority pollutant analyses of water samples.

An equipment blank (015) was determined to contain nickel at a concentration of 0.014 mg/l. This result is not considered to have a significant effect on the reported nickel values as the MDL specified in the SOW (0.015 mg/l) is greater than the concentration in the equipment blank.

Analyses for priority pollutant metals in soil and sediment samples were performed in accordance with the EPA Methods summarized in Appendix H.9.a. A complete enumeration of the procedures which comprise these (CL5142A/1)

analytical methods can be found in EPA's "Test Methods for Evaluating Solid Waste:" SW846, September, 1986. The results of priority pollutant metals analyses for soil and sediment samples can be found in Appendix H.7.

Table F.2.16 in Appendix F.2 provides a chronology for soil and sediment samples from the date of collection until priority pollutant analyses. The holding times for metals analyses specified in the USAFOEHL Sampling Guide (July, 1985) for water samples are applicable to soil samples as well. All soil and sediment samples were analyzed for priority pollutant metals within the specified holding times.

Soil samples 001 through 008 were analyzed for lead. A laboratory duplicate of sample 003 yielded a RPD value of less than 1. This sample also produced a spike recovery of 98 percent. Thus, these lead results for soil samples are judged to be accurate.

Soil samples 009, 010 and 011 were extracted and analyzed for 13 metals in conjunction with the analyses of water samples. QC documentation of metals analyses performed on water samples can be applied to results for these three soil samples. Refer to the previous discussion on metals results for water samples to determine the validity of soil results.

C.7 Laboratory Results for Replicate Samples

Laboratory analytical results for field replicate samples are provided on Table F.2.33 in Appendix F.2. These results are provided to allow a qualitative assessment of the representativeness of samples and the reproducibility of laboratory analytical results. EPA/CLP protocols maintain that RPD values are not calculated for field replicate samples and, for this reason, EPA/CLP does not specify acceptable ranges for RPDs calculated from the results of analyses of field replicate samples. Generally, the results of analyses of field replicate samples show good correlation except where detected concentrations are near the analysis' MDL.

D. Significance of Findings

The significance of the sampling analyses results is largely dependent upon the environmental setting in which sampling took place. The geology and hydrogeology of the region in which MAFB is situated was presented in detail in Chapter II of this report. Regional geologic and hydrogeologic information was obtained through a thorough background literature review. Virtually no information was available regarding site specific geology and hydrogeology. Site specific information presented in Chapter II was extrapolated from available regional information. The following two subsections (D.1 and D.2) present site specific geologic and hydrogeologic information obtained through the HART Phase II field investigation.

D.1 Site Geology

The field investigation conducted by HART at MAFB involved drilling a total of thirteen test borings. Eight test borings were drilled in the SLA; four test borings were drilled in the FTA; and one test boring was drilled in the EOD. Test boring locations in the SLA and the FTA can be found on Figures IV-1 and IV-2, respectively. In addition, samples were retained for both permeability testing and grain size analyses. These samples were chosen from a variety of materials with the intent of establishing a varied database to represent all types of deposits encountered. Table IV-16 outlines the results of the geotechnical analyses. These results will be discussed later in this section. A complete set of geotechnical analyses results is provided in Appendix H (Subsections H.10 and H.11).

The local geologic conditions, as determined from borings drilled on site, are consistent and support the regional geologic descriptions as defined by Pettyjohn and Hutchinson (1971) and Kehew (1983) and as discussed in sections B.1, B.2 and C of Chapter II.

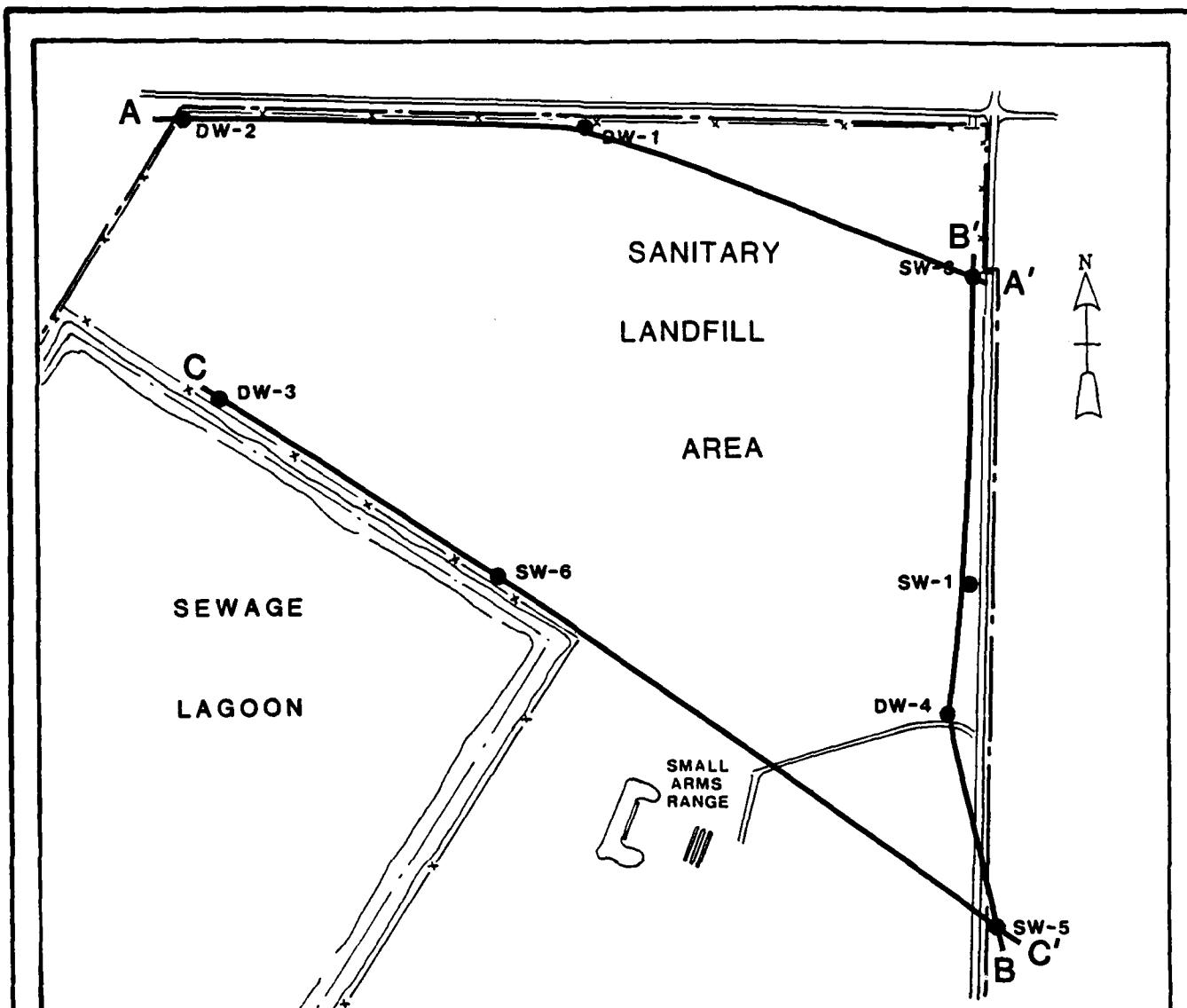


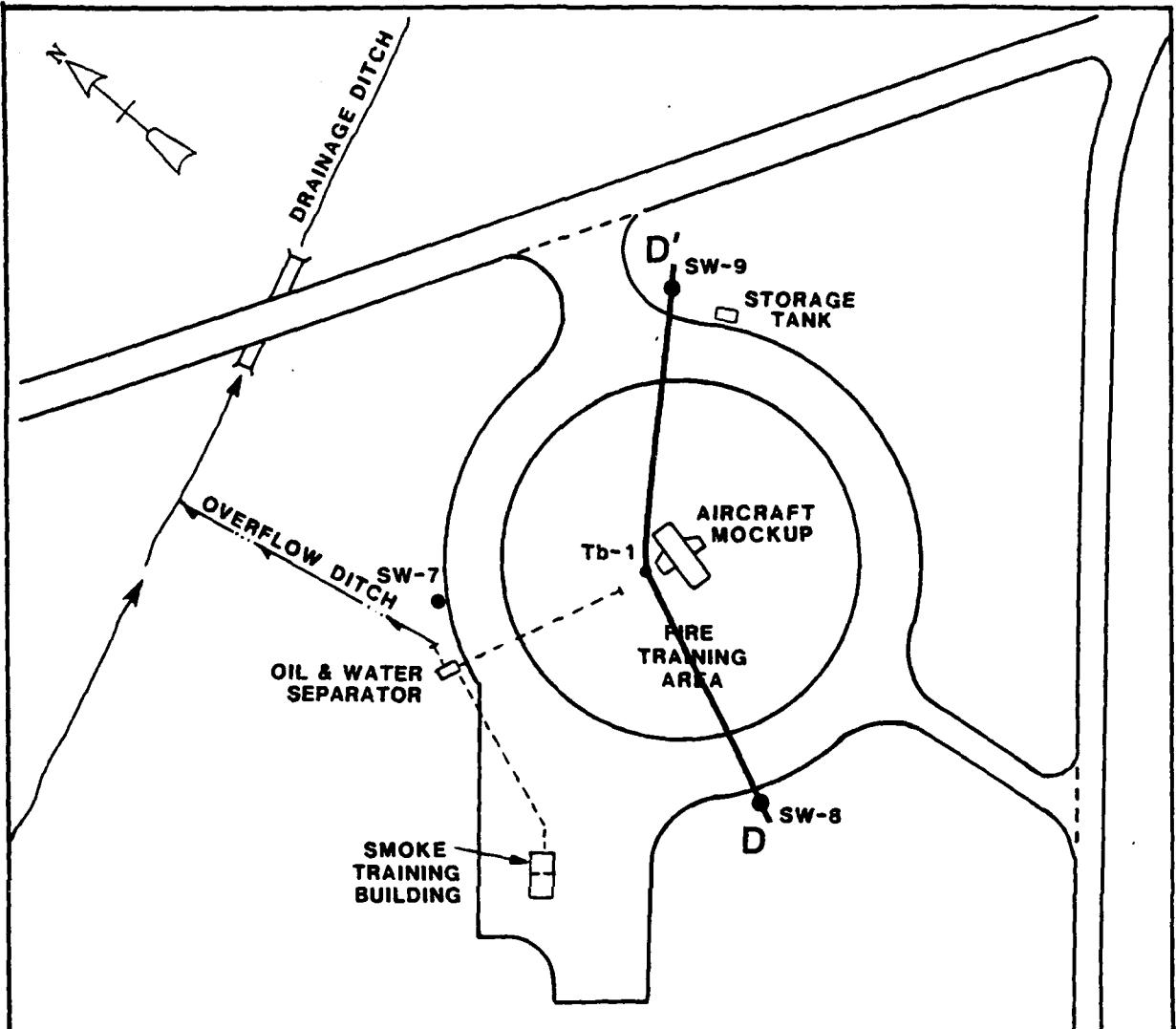
FIGURE IV-1

LOCATIONS OF TEST BORINGS
AND GEOLOGIC CROSS-SECTIONS
IN THE SANITARY LANDFILL AREA

MINOT AIR FORCE BASE

NOTE: For Cross-Sections A-A', B-B' and C-C'
see FIGURES II-9, II-10 and II-11.

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NOTE: For Cross-Section D-D'
see FIGURE II-12.

FIGURE IV-2
LOCATION OF TEST BORINGS
AND GEOLOGIC CROSS-SECTION
IN THE FIREFIGHTING
TRAINING AREA
MINOT AIR FORCE BASE

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TABLE IV-16

RESULTS OF GEOTECHNICAL ANALYSIS OF SOIL SAMPLES

<u>Grain Size Analysis</u>			<u>Visual Description of Sample</u>	<u>Classification Based on Grain Size Curve</u>	<u>Permeability cm/sec.</u>	<u>Type of De-</u>
<u>Boring</u>	<u>Sample No.</u>	<u>Depth Taken (ft)</u>				
SW-1	SS-6	10-12	Fine to medium, orange-brown sand with trace of silt, coarse sand and gravel.	Coarse to fine, silty SAND.	-	Sand
SW-3	SS-4	15-17	Brown silty clay with occasional orange mottling and pebbles.	Medium to fine sandy SILT with trace of coarse sand.	-	Till
SW-5	SS-7	12-14	Fine brown sand with some silt.	Medium to fine silty SAND.	-	Sand
SW-8	SS-6	13-15	Light brown silty clay with trace of sand and pebbles.	Medium to fine sandy SILT.	-	Till
SW-9	SS-6	15-17	A mixture of silty fine sands and silty clay with some pebbles and cobbles.	Silty, coarse to fine SAND.	-	Alternat Sand and
DW-1	SS-10	45-47	Dark gray silty clay with trace of sand and pebbles.	Coarse to fine sandy SILT.	-	Till
DW-2	SS-9	40-42	Mixture of fine silty sand and dark gray silty clay.	Coarse to fine SAND and SILT with some fine gravel.	-	Alternat Sand and
DW-4	SS-14	38-40	Fine to medium, gray silty sand with some pebbles.	Silty, coarse to fine SAND.	-	Sand
<u>Permeability Analysis</u>						
SW-1	ST-1	14-16	Light brown silty clay with occasional pebbles and gravel.	Coarse to fine sandy, SILTY CLAY.	4.63×10^{-7}	Till
SW-8	ST-1	15-17	Light brown silty clay grading into a gray clay.	Medium to fine sandy SILT.	3.29×10^{-7}	Till
SW-9	ST-1	15-17	Alternating silty fine sands and silty clays.	Silty, fine to coarse SAND.	1.63×10^{-6}	Alternat Sand and

TABLE IV-16 (Continued)

RESULTS OF GEOTECHNICAL ANALYSIS OF SOIL SAMPLES

<u>Grain Size Analysis</u>	<u>Boring No.</u>	<u>Sample No.</u>	<u>Depth Taken (ft)</u>	<u>Visual Description of Sample</u>	<u>Classification Based on Grain Size Curve</u>	<u>Permeability cm/sec.</u>	<u>Type of De</u>
DW-1	ST-1	46-48		Dark gray silty clay with trace of sand and pebbles.	Coarse to fine sandy SILT.	Sample Disturbed, Could not be Analyzed	Till
DW-4	ST-1	20-22		Dark grey silty clay with trace of sand and pebbles.	Coarse to fine sandy, SILTY CLAY.	6.46×10^{-7}	Till

Figure IV-3 shows the grain size curves for samples that were taken from the upper and lower till zones. The curves labeled SW-3 and SW-8 are for samples taken in the upper zone at 15 to 17 and 13 to 15 feet, respectively. The curves labeled DW-1(A) and DW-1(B) and DW-2 are for samples taken in the lower zone at 45 to 47 feet, 46 to 48 feet and 40 to 42 feet, respectively. These curves illustrate the unsorted nature of the till as evidenced by the sediment sizes ranging from gravel to clay. These curves also illustrate the similarity in composition between the upper and lower zones within the till.

The curves for DW-1(A) and (B) deviate slightly from the trend of the curves for SW-3, SW-8 and DW-2 because they contain a slightly higher percentage of sediment coarser than silt or clay. DW-1(A) actually contains enough sand size particles to be classified as a silty sand. However, because these classifications are based on percent by weight of sediments finer than a given size, they do not always accurately define the sediments classification. In the case of DW-1(A) and (B), the curves are lower and skewed to the left because sand and gravel are much heavier than clay and silt and therefore have a greater effect upon the curves. Although these samples contained a higher percentage of sand and gravel size particles, it is not considered significant because the amount of coarse sediment present varied from sample to sample in both the upper and lower zones within the till. It is reasonable to assume, therefore, that the upper and lower zones within the till are the same unit and are only subdivided on the basis of color as a result of oxidation.

The test boring program conducted by HART confirms the horizontal and vertical continuity of the till. In each test boring, the predominantly silt and clay till consisted of a light brown oxidized zone underlain by a dark gray unoxidized zone (see boring logs in Appendix D).

Test borings DW-1 and DW-4 were the deepest borings drilled (100 ft). These borings indicate the till extends to at least a depth of 100 ft; however, no attempt was made to confirm the estimate that the till extends to a depth ranging from 150 to 220 feet.

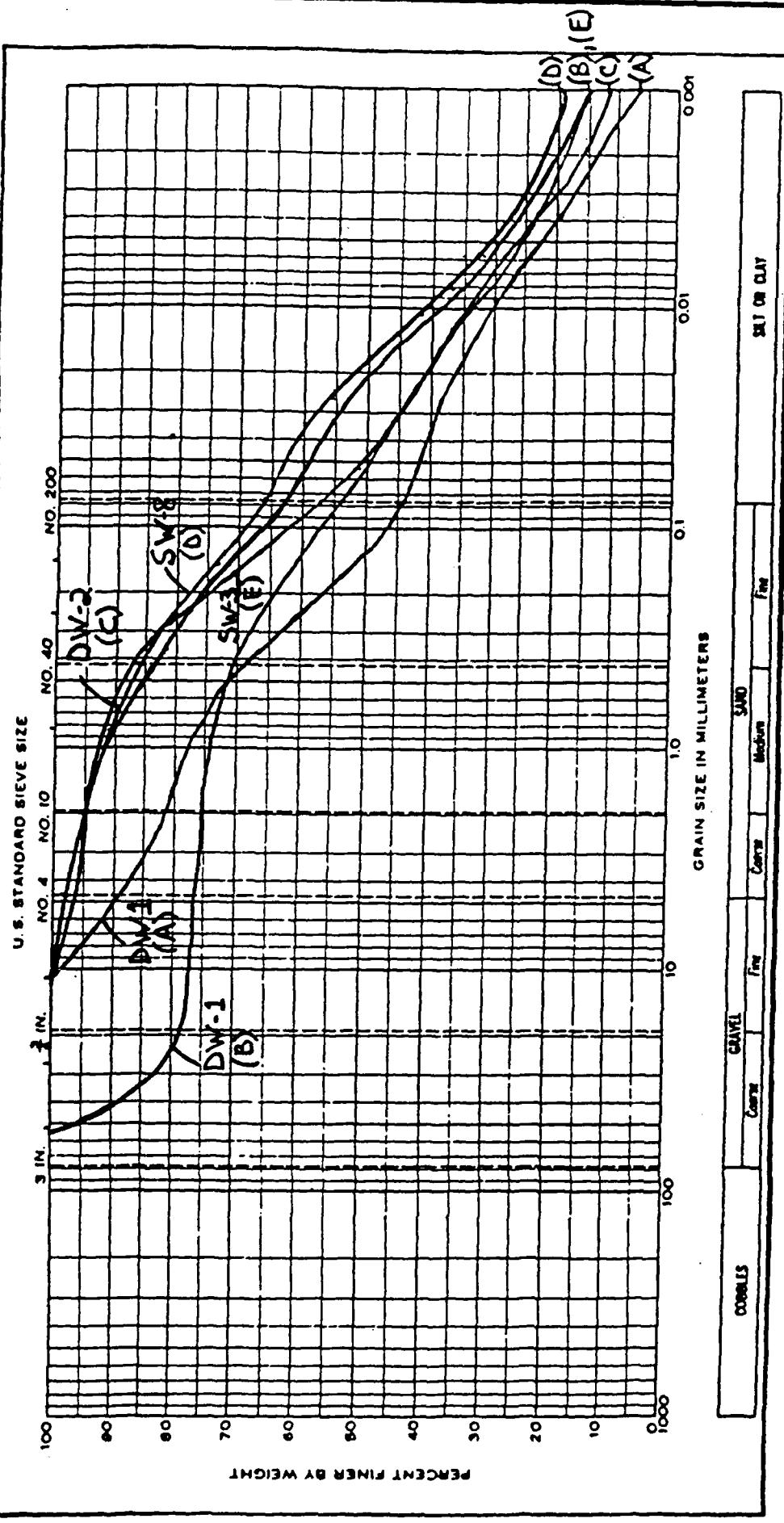


FIGURE IV-3

GRAIN SIZE CURVES
FOR TILL SAMPLES

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Two types of minor deposits exist in the study area interspersed in the till: (1) laterally and vertically discontinuous, stratified to unstratified sands and gravel deposited in a variety of glacial settings including ice marginal channels and outwash plains; and (2) recent, surface silts and clays consisting predominantly of reworked till sediment confined to prairie potholes and intermittent stream channels. Kehew (1983) mapped the occurrence of the various recent surface deposits which are assigned to the Oahe Formation. Oahe Formation sediments located at the MAFB are illustrated on Figure II-3.

The above-mentioned sand and gravel deposits at MAFB are buried within the till, except in a few isolated instances where the deposits are overlain by only a few feet or less of Oahe Formation sediments (SW-5 is an example). The sand and gravel deposits comprise only a small portion of the section of glacial sediments. From data obtained from boring logs, it is estimated that the sand and gravel deposits account for less than 5% of the total volume of the first one hundred feet of glacial sediments (based on total estimated footage of sand encountered/total footage of borings x 100).

Sand and gravel deposits were encountered in seven of the eight test borings in the SLA (SW-1, SW-3, SW-5, SW-6, DW-1, DW-2 and DW-4) and in two of the four test borings in the FTA (SW-9 and TB-1). The fact that sand or gravel were not encountered in the remaining four test borings does not necessarily preclude the existence of sand or gravel in those borings. This notion is supported for two reasons; first, in two of four borings (SW-7 and TB-2) samples were taken only at 5-foot intervals, which, with a 2-foot sampler, leaves a 3-foot unsampled zone. Second, it is possible that sand was encountered but not retained given that the sampler did not always have full recovery, even with continuous sampling. It is suggested that these sand and gravel deposits represent discontinuous stringers and lenses.

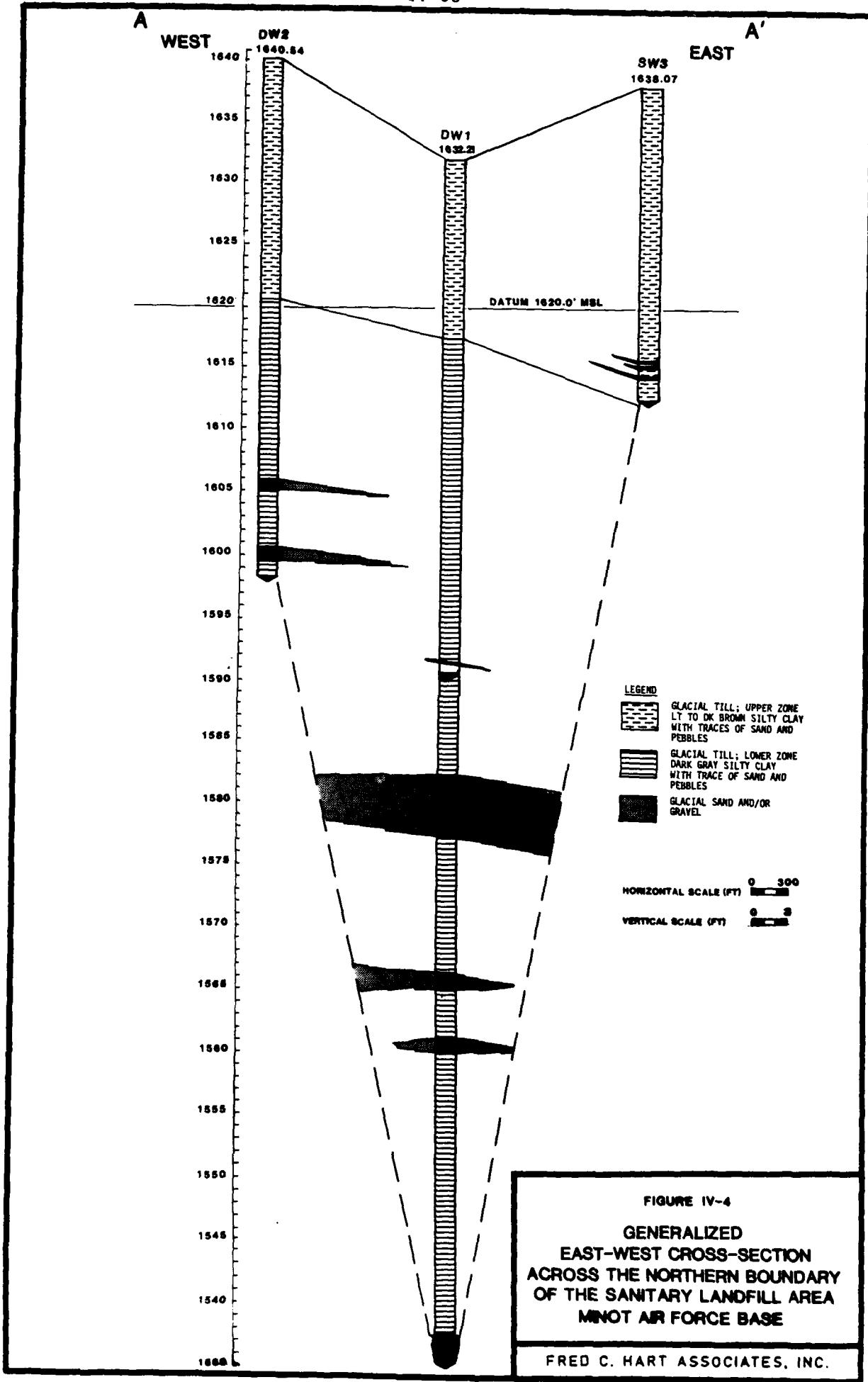
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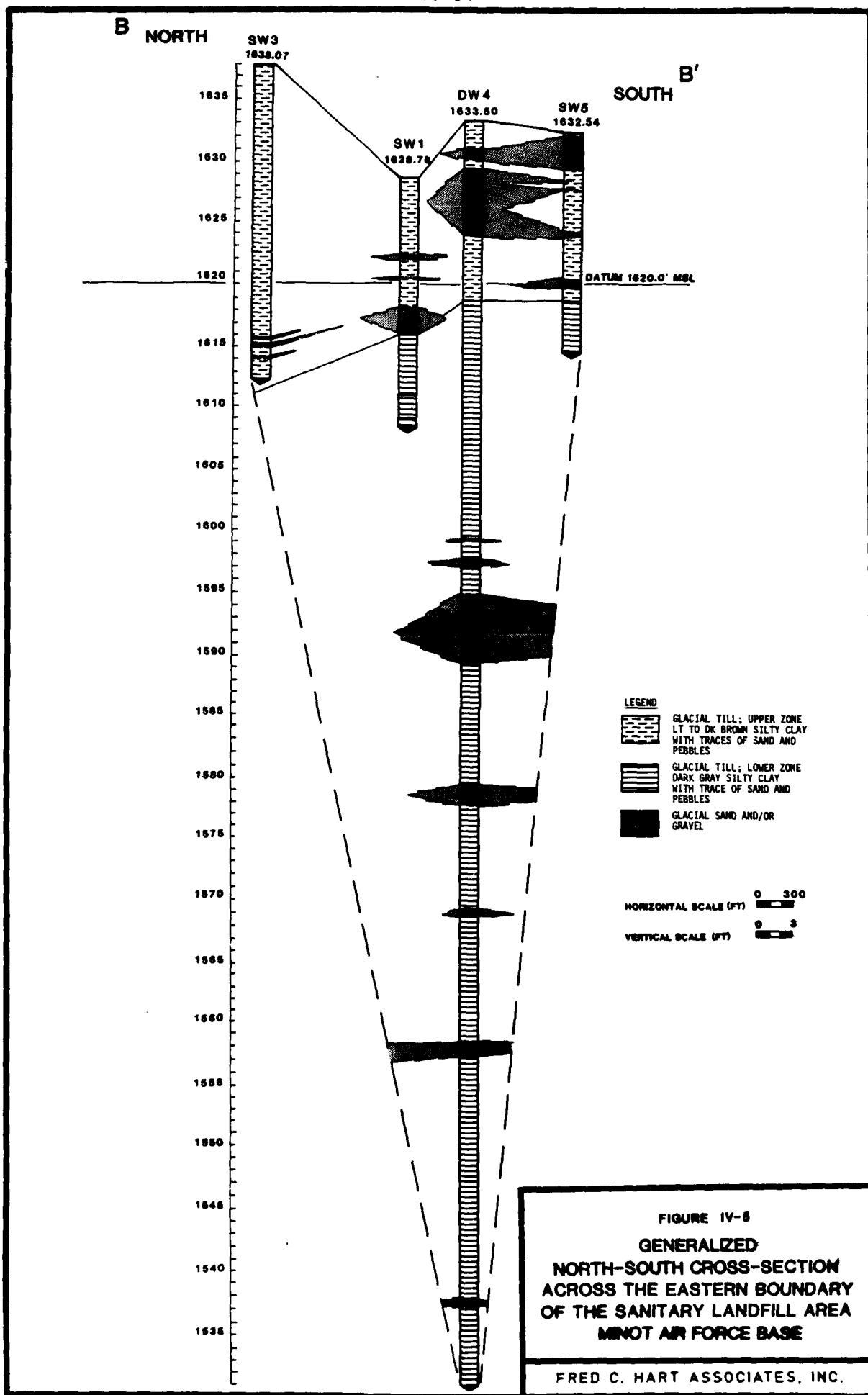
The cross-sections shown in Figures IV-4, IV-5, IV-6 and IV-7 depict the lenticular and discontinuous nature of the sand and gravel deposits buried within the till. Locations of all geologic cross-sections can be found in Figures IV-1 and IV-2. The data available from the HART boring program indicates that the average sand and gravel deposit is less than two feet thick and that these deposits rarely exceed four feet in thickness (see boring logs in Appendix D).

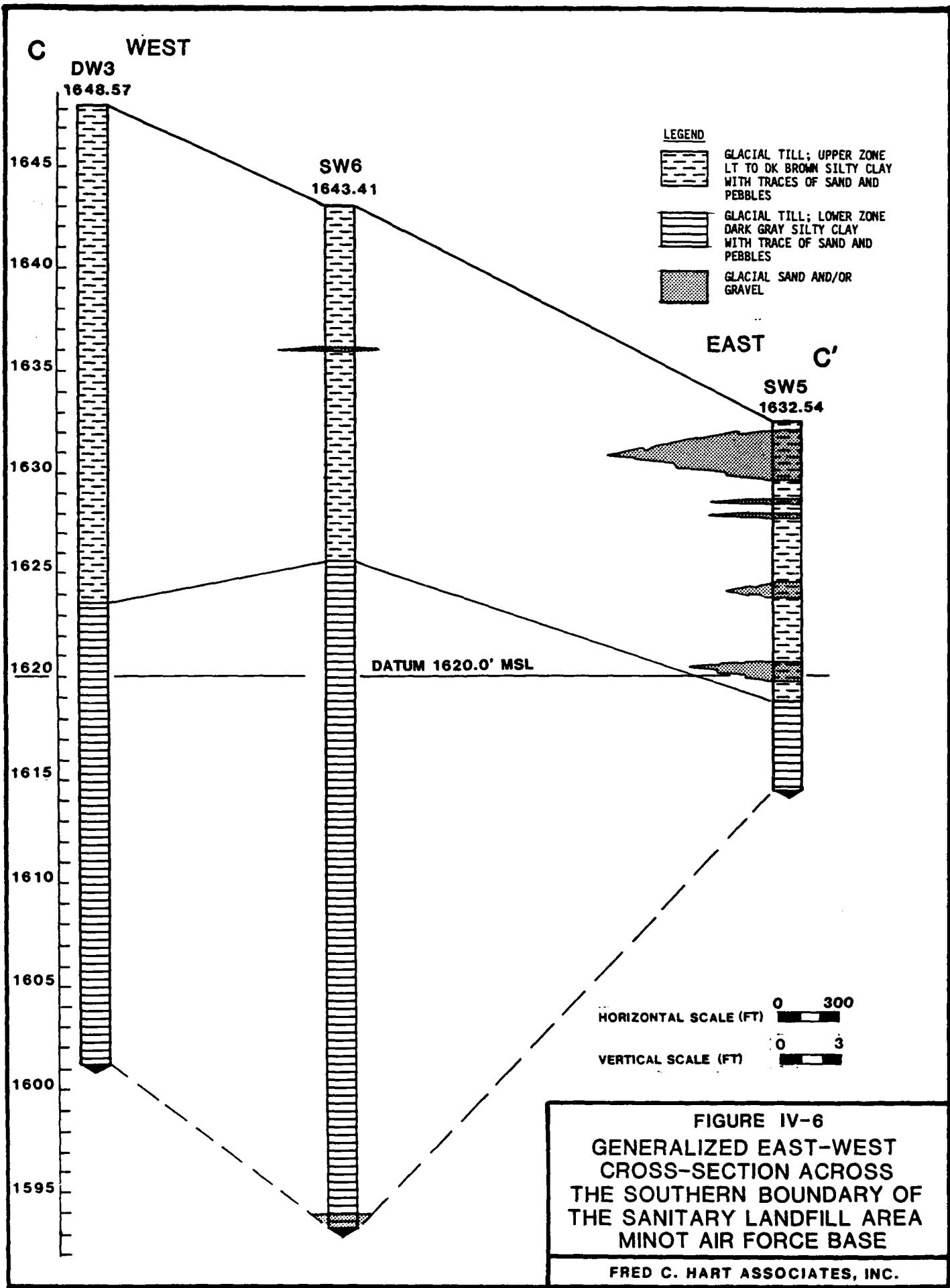
Figure IV-8 shows the grain size curves for five samples of sand retained for geotechnical analyses during the HART test boring program. The visual description of these samples (see boring logs in Appendix D or Table IV-16) qualitatively describes the amount of grain size variation within these sand and gravel deposits. Color, grain size, degree of sorting and roundness of the grains varied with almost every sand lens encountered. These grain size curves give a quantitative indication of the grain sizes present and the degree of sorting (a complete set of geotechnical analysis results is included in Appendix H). Sample SW-5, which is 65% by weight fine sand, is an example of a fairly well-sorted sand. Sample DW-2, containing 25% gravel, 5% coarse sand, 10% medium sand, 35% fine sand and 25% silt and clay, is an example of a poorly sorted sand.

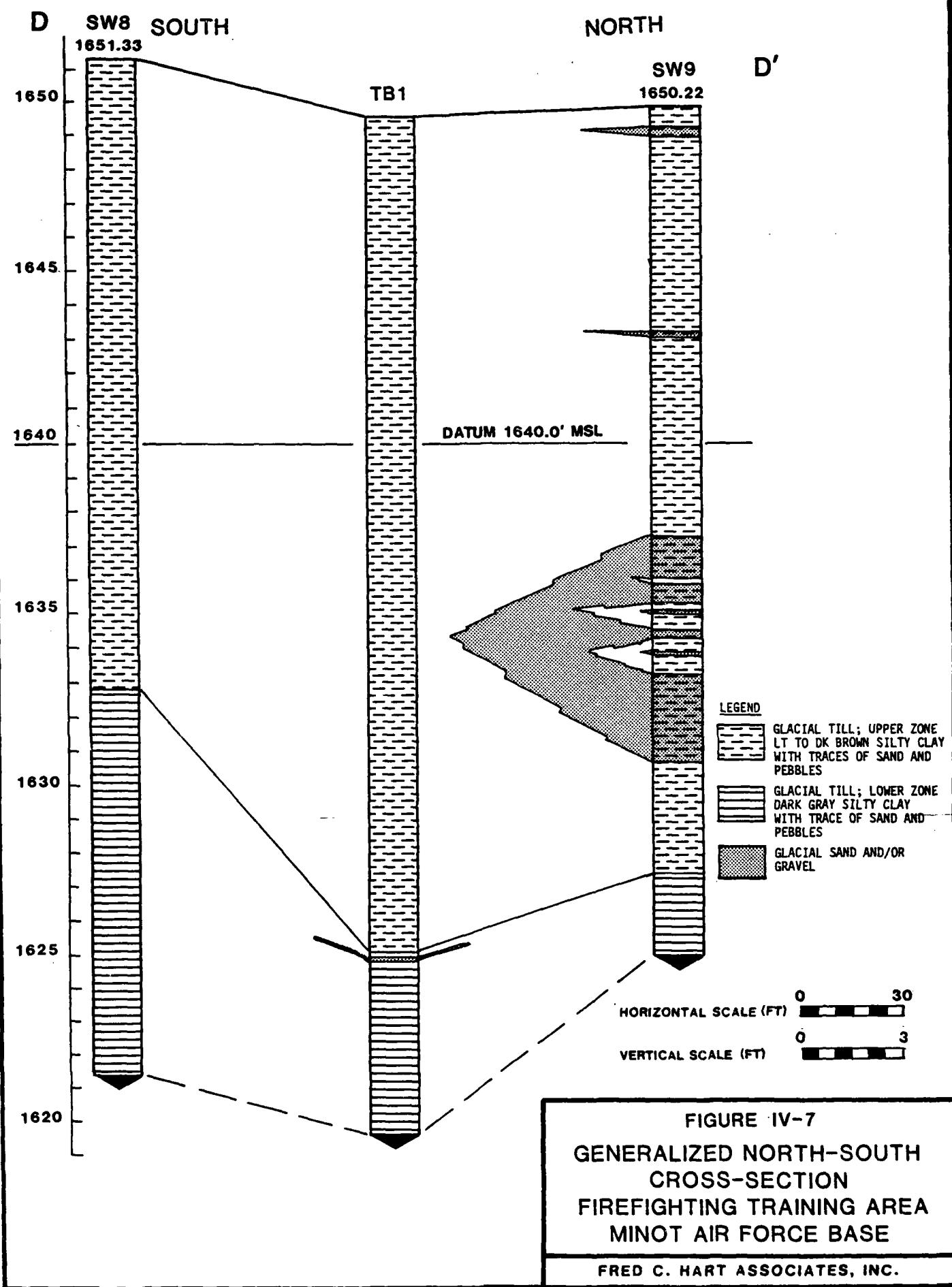
The large variation in types of sediment present and the variation in the depths at which these sand and gravel deposits occur made correlation of the deposits very difficult. In only one of the four cross-sections were sand lenses in adjacent boreholes correlated (Figure IV-5). These sand and gravel deposits were correlated on the basis of their occurrence at similar depths and their lateral proximity.

The geology beneath of MAFB differs from boring to boring with respect to the depth the unoxidized zone of the silt and clay till is encountered and the occurrence and types of sand and gravel encountered. However, the overall geology is very consistent. The oxidized and unoxidized zones of (CL5142A/1)









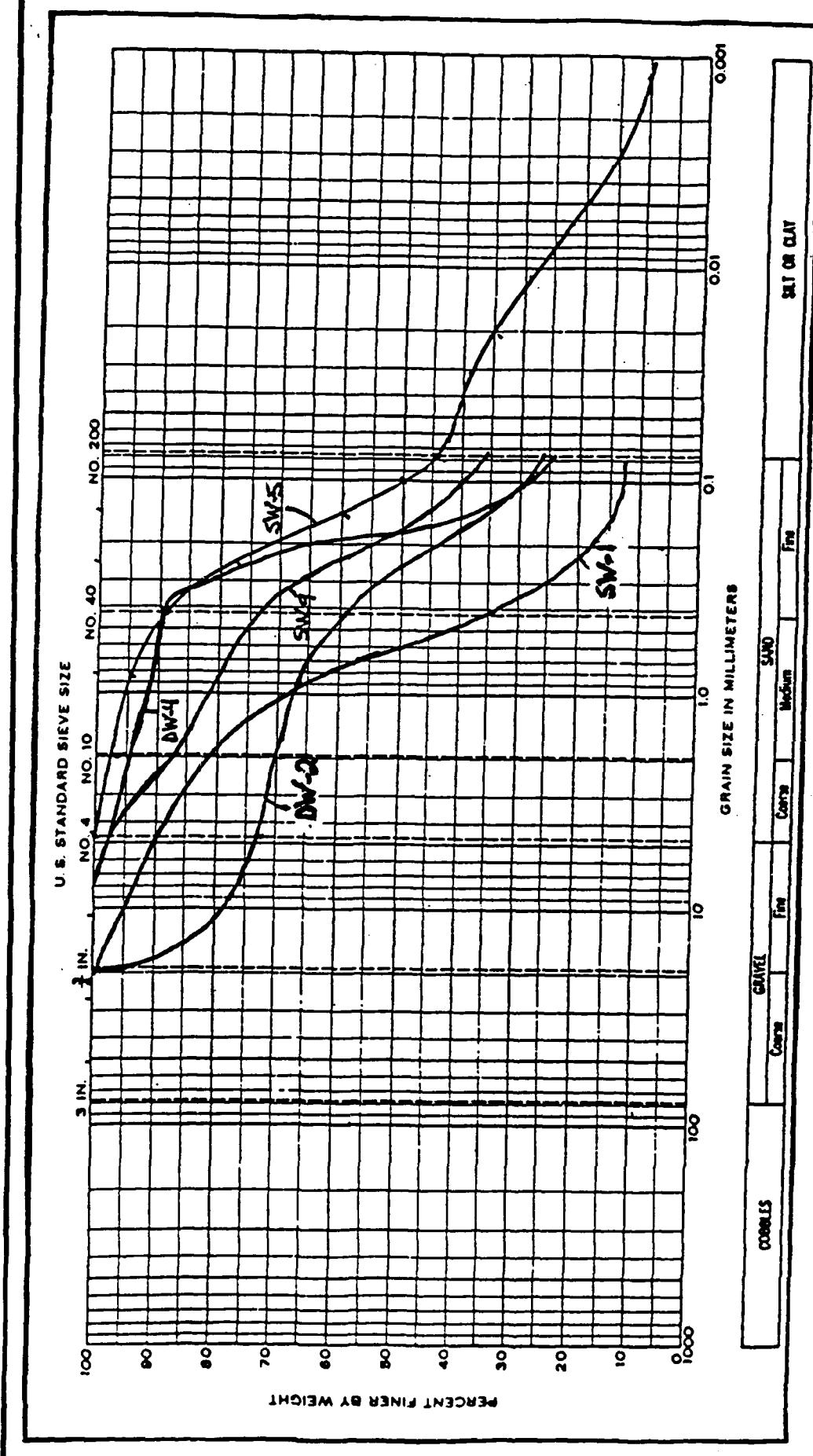


FIGURE IV-8
GRAIN SIZE CURVES
FOR SAND SAMPLES

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the till are always present and the sand and gravel deposits are pervasive within the till. Therefore, it is reasonable to conclude that the geology underlying each of the areas of investigation at MAFB--the SLA, the FTA and the EOD--is equivalent and a detailed discussion of each of the areas is unnecessary.

D.2 Site Hydrogeology

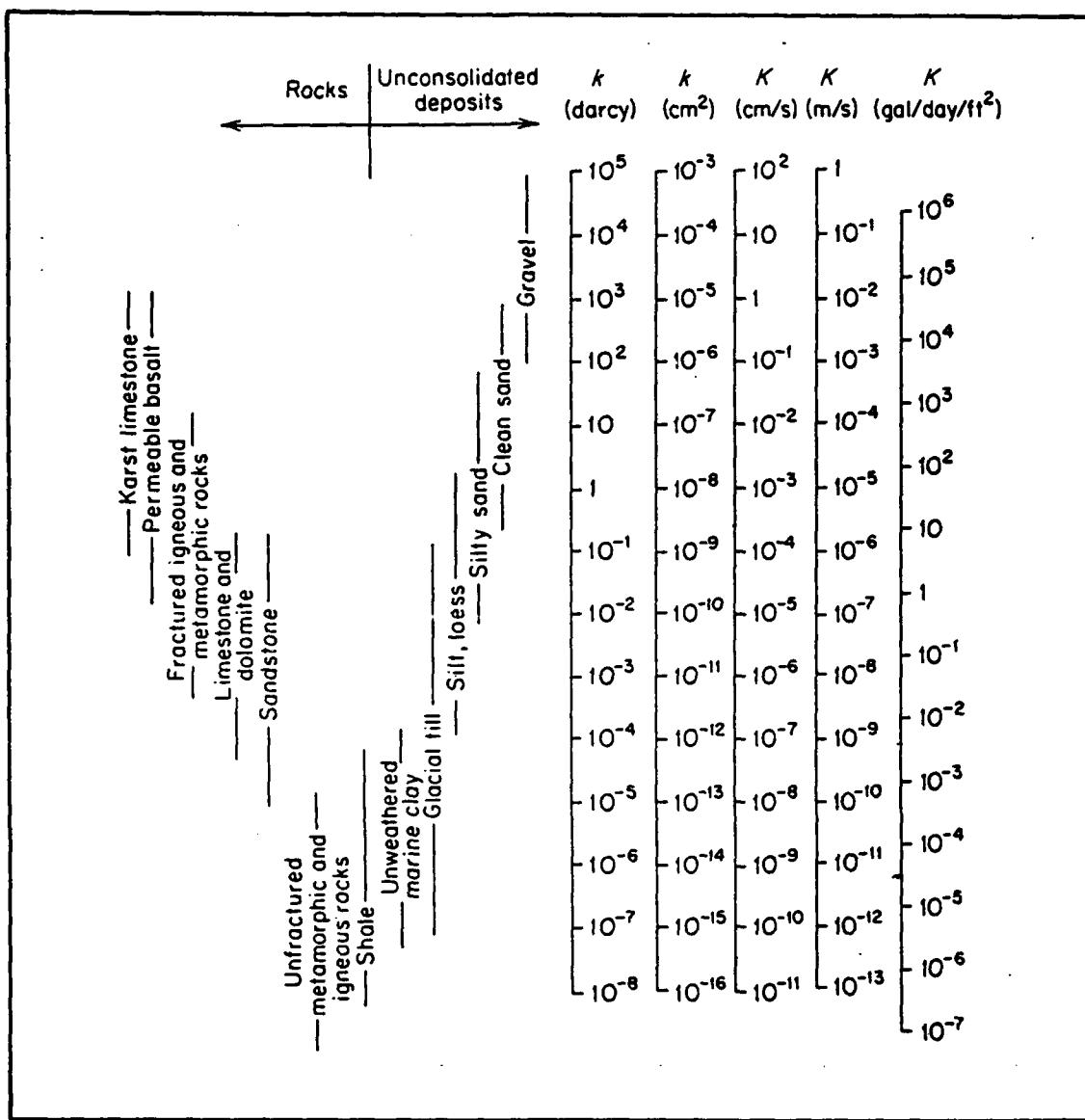
As part of HART's field investigation, ground water monitoring wells were installed at the SLA and FTA. At the SLA, four deep wells and six shallow wells were installed and are shown in Figure III-5. Two shallow wells were installed in the FTA and are shown in Figure III-6. The ground water monitoring wells and geotechnical analyses results for soil samples illustrate that it is very difficult to establish the configuration of the ground water table within the glacial till underlying MAFB. Despite its degree of saturation, till generally yields little or no water to wells. For example, shallow well SW-2 was screened from 10 to 20 feet as split-spoon samples indicated this zone to be saturated. Analyses of Shelby tube samples (Appendix H) taken at similar depths in other boreholes also indicated a saturated unit. Shelby tube SW-1, ST-1, 14 to 16 feet was 97.9% saturated and Shelby tube SW-8, ST-1, 15 to 17 feet was 97.6% saturated. The light brown, silty clay contained within both these Shelby tubes supported the visual description of the soil in the screened interval of SW-2. However, the well remained dry for at least three days following completion. Approximately two weeks after the well was installed, the water level reading indicated that there was 1.45 feet of standing water in the well. Although the water level may have eventually risen to a height approximating the ground water table surface, it is apparent that this method would not have been accurate and reliable for assessing the elevation and configuration of the ground water table surface. Therefore, it is reasonable to assume, based on visual descriptions of moisture content during the drilling of soil borings, that the till approaches complete saturation at depths ranging from 3 to 15 feet in the study area.

In contrast to the glacial till, the sand lenses interbedded throughout the till have relatively high water-yielding characteristics. Grain size analyses (Appendix H) indicate that these sand lenses are generally composed of silty sand. The range of permeabilities for silty sand is 10^{-5} to 10^{-1} cm/sec (Figure IV-9). However, the water yielding capabilities of these sand lenses are strictly limited by their areal and vertical extent and by the water yielding capabilities of the surrounding glacial till.

The HART boring program indicated that these sand lenses are of limited areal extent and typically do not exceed two feet in thickness; thus, their capacity to yield significant amounts of water is limited, as was demonstrated when monitoring wells were bailed prior to sampling. With the exception of SW-2, the screened interval of all HART wells contains at least one sand lens. All of the wells were bailed dry and required from 5 to 24 hours to recover. The extended period of time required for these wells to recover is due to the low yield of the glacial till surrounding the sand lenses. This notion is supported by water level data from HART wells located at MAFB. Water levels in shallow wells were higher than water levels in deep wells (Table IV-17), which indicates a limited hydraulic connection between shallow and deep sand lenses as a result of the impermeability of the till.

Since deposits composed predominantly of sand account for less than 5% of the total volume of the first 100 feet of glacial sediments, it is clear that the rate of vertical movement thorough the glacial sediments is controlled by the permeability of the glacial till. The reported range of permeabilities for a clay and silt till is from negligible to 10^{-4} cm/sec (Powers, 1981 and Freeze and Cherry, 1979). Triaxial permeability test results from Shelby tube samples taken in the glacial till (Appendix H.11) indicate that the permeability of the till is in the range of 33×10^{-8} to 65×10^{-8} cm/sec.

(CL5142A/1)



SOURCE: Freeze and Cherry, 1979

FIGURE IV-9

RANGE OF VALUES OF
HYDRAULIC CONDUCTIVITY
AND PERMEABILITY

FRED C. HART ASSOCIATES, INC.

TABLE IV-17
WATER LEVEL DATA

WELL #	ELEVATION TOP OF PVC CASING	WATER LEVEL PRIOR TO DEVELOPMENT	WATER LEVEL PRE-SAMPLING BAILING	WATER LEVEL PRIOR TO SAMPLING	WATER LEVEL ON 10/31/86
SW-1	1630.98	1624.12	1624.06	1623.98	1624.02
SW-2	1634.25	1616.10	1615.02	NM	1615.64
SW-3	1640.07	1628.11	1621.63	1624.04	1620.29
SW-4	1635.53	1627.21	1627.13	1627.05	1627.06
SW-5	1634.54	1626.37	1626.34	1626.08	1626.27
SW-6	1645.81	1639.68	1639.26	1639.05	1639.26
SW-8	1653.33	1645.53	1645.46	1645.23	1645.43
SW-9	1652.22	1644.43	1644.25	1643.18	1644.16
DW-1	1634.17	1628.06	1624.28	1619.51	1621.82
DW-2	1642.54	1634.12	1632.46	1632.38	1632.24
DW-3	1650.47	1629.19	1615.08	1608.78	1626.85
DW-4	1635.47	1626.19	1624.09	1621.62	1623.47
MW-1	1639.55	ND	1636.27	1626.07	
MW-2	1636.74	ND	1629.96	1617.89	
MW-3	1635.38	ND	1629.38	1622.13	
MW-4	1642.51	ND	1631.24	1621.21	

NM = No Measurement.

ND = Not Developed by HART.

The fact that water levels in shallow wells are higher than those in deep wells indicates a vertical downward component of ground water flow. Estimates of the potential vertical movement of ground water through the till can be computed by a technique found in Fetter (1980). Vertical movement (v) can be calculated using the head (water level) of an upper sand lens (h_0), the head in a lower sand lens (h), the thickness of the till separating the two sand lenses (b'), and the vertical hydraulic conductivity of till (K') in the following equation:

$$v = K' \frac{(h_0 - h)}{b'}$$

Well nest DW-4/SW-4 is used to illustrate the potential for vertical movement through the till.

Data:

- 1) SW-4: screened interval 6 to 16 feet; interbedded sand lenses from 4.5 to 10.5 feet; water level on 10/31/86 1,627.06 feet msl (Appendix D and Table IV-17).
- 2) DW-4: screened interval 34 to 44 feet; interbedded sand lenses from 38 to 43 feet; water level on 10/31/86 1,623.47 ft. msl (Appendix D and Table IV-17).
- 3) Shelby tube DW-4, ST-1, 20 to 22 feet (till); computed permeability of 6.46×10^{-7} cm/sec. (Appendix H).

K' = hydraulic conductivity (approximately equal to permeability) = 6.46×10^{-7} cm/sec

h_0 = 1,627.06

h = 1,623.47

Calculation: $(h_0 - h) = 3.59$ ft = 109.42 cm

b' = (thickness of till between sand lenses) = 27.50 ft = 838.20 cm

(CL5142A/1)

$$V = 6.46 \times 10^{-7} \frac{\text{cm}}{\text{sec}} \times \frac{109.42 \text{ cm}}{838.20 \text{ cm}} = 8.43 \times 10^{-8} \frac{\text{cm}}{\text{sec}}$$

thus, $v = 2.66 \text{ cm/year}$.

Therefore, the rate of movement of water from the upper sand lens to the lower sand lens would be approximately 3 centimeters of movement of water vertically downward per year. Vertical migration of water through this clay unit from the upper to lower sand lens would take approximately 300 years; thus, the clay present is an effective barrier to the rapid vertical movement of any potential contaminants. Although it is likely that this value varies throughout the till, the nature of the till suggests that it probably does not vary by more than a half an order of magnitude.

It is a common practice in hydrogeologic investigations to plot water level elevations in wells on a base map and contour the data. These maps are used to give an indication of ground water flow, which is normally perpendicular to contour lines. There are two types of water level contour maps: water table and potentiometric surface maps.

In order to construct a water table contour map, a number of shallow wells open along their length and penetrating the surface deposits need to be installed deep enough to penetrate the upper surface of the zone of saturation and, thus, the water table. The water level elevations in the wells are then plotted on a base map to be contoured. However, as discussed earlier in this section, accurate determinations of the elevation of the zone of saturation could not be made by this method because till generally yields little or no water to wells despite its degree of saturation. The only wells at MAFB that do produce any significant amount of water from the glacial deposits are those wells that contain sand lenses within the screened interval. However, the water levels in these wells does not indicate the height of the zone of saturation; instead, the water level is a reflection of the hydraulic head of the sand lens or lenses (CL5142A/1)

contained within the screened interval of a particular well. Thus, no water table contour map can be constructed for the saturated sediments underlying MAFB.

The type of water level contour map that is constructed from hydraulic head measurements is known as a potentiometric surface map. A potentiometric surface map can only be constructed for confined aquifers. The sand lenses contained within the till may be considered confined aquifers, since they are units of relatively high permeability confined by till of low permeability.

The concept of a potentiometric surface is only valid for horizontal flow in a continuous, horizontal aquifer (Freeze and Cherry, 1979). The wells at MAFB are receiving water from lenticular and discontinuous sand deposits that cannot be considered a single, horizontal, continuous aquifer. In addition, if there are vertical components of flow, calculations and interpretations based on this type water level contour map can be very misleading (Freeze and Cherry, 1979). It has already been established that the vertical component of flow is the dominant component in the glacial sediments underlying MAFB. Thus, calculations and interpretations regarding the direction and rate of ground water flow based on a potentiometric surface map (or water level contour map for confined sand lenses) would be in error.

D.3 Comparison of Analytical Results to Available Criteria

The discussions presented in Section B of this chapter indicate that the MDLs used by PTL in their analyses of MAFB water samples exceeded the MDLs specified in the MAFB IRP Phase II SOW for certain parameters. However, the discussions presented in Section B of this chapter also indicate that none of the MDLs used by PTL exceeded an established, enforceable water quality standard. For this reason, the MDLs used by PTL are considered sufficient in evaluating the significance of analytical (CL5142A/1)

results for water samples. The discussions in Section C of this chapter indicate that, due to either inadequate QC analyses results or a lack of QC documentation, many of the analytical results (positive detections) and MDLs for non-detect results should be considered estimated values. Due to inherent difficulties associated with comparing estimated values to established quality criteria, the laboratory analytical results are considered accurate for the purpose of evaluating the significance of analytical results for water samples.

Analytical results of surface water and ground water samples indicate that 19 contaminants have been detected in ADL concentrations. These contaminants include 5 of 13 priority pollutant metals, all of the common anions, five compounds classified as halogenated volatile organics, total dissolved solids (TDS) and petroleum hydrocarbons. Table IV-18 shows the 19 constituents, along with all available quality criteria established for these constituents. A discussion of these quality criteria and their relation to the detected constituents follows. Tables IV-19, IV-20 and IV-21 show the range of concentrations for detected constituents in SLA surface water, SLA ground water and FTA ground water samples, respectively, and all applicable criteria.

Pursuant to Section 1412 of the Safe Drinking Water Act (SDWA), the Environmental Protection Agency (EPA) has promulgated "National Interim Primary Drinking Water Standards" (NIPDWS) for certain organic and inorganic substances. These standards establish "maximum contaminant levels" (MCLs) which specify the maximum permissible level of a contaminant in water which may be delivered to a user of a potable water system (now defined as serving a minimum of 25 people). MCLs are established based on consideration of a range of factors including health effects of the contaminants and the technological and economic feasibility of the contaminant's removal from the supply. Each state must in turn adopt drinking water standards at least as stringent as the federal standards. The State of North Dakota has adopted the MCLs specified in the NIPDWSs.

TABLE IV-18

AVAILABLE FEDERAL AND STATE WATER QUALITY CRITERIA FOR CONSTITUENTS DETECTED IN WATER SAMPLES

<u>Detected Constituent</u>	<u>NIPDWS's¹</u>	<u>NSDWS's²</u>	<u>RNCL's³</u>	<u>SNARL's⁴</u>	<u>PPCL's⁵</u>	<u>NDADS's⁶</u>	<u>EPAAMQC⁷</u>
<u>Priority Pollutant Metals</u>							
Copper	-	1.0	1.30 ^b	-	-	0.05	1,000
Nickel	-	-	-	750(AD1); 0.03(UCR)	-	-	13.4
Lead	0.05	-	0.02 ^b	155(AD1); 50(MCL)	0.05	50	-
Zinc	-	5.0	-	7,500(AD1)	1.0	5,000	-
Silver	0.05	-	-	50(MCL)	-	50	-
<u>Common Anions</u>							
Chloride	-	250	-	-	100	-	-
Fluoride	-	2.0	-	-	-	-	-
Bromide	-	-	-	-	-	-	-
Nitrate	10.0	-	10.0 ^b	-	-	1.0	-
Nitrite	-	-	1.0 ^b	-	-	-	-
Phosphate	-	-	-	-	0.1	-	-
Sulfate	-	250	-	-	-	250	-
Total Dissolved Solids	-	500	-	-	-	-	-
<u>Halogenated Volatile Organics</u>							
1,1,2-Dichloroethane	5.0 ^a	-	0.0	-	0.51(UCR); 0.95(UCR)	-	0.94
1,1,1-Trichloroethane	0.20 ^a	-	0.20	1.0 ^c	19,000(AD1); 21.9(UCR)	-	18,400
Bromodichloromethane	0.10	-	-	-	19.5(AD1)	-	0.19
Trichloroethene	5.0 ^a	-	0.0	2.0	-	-	2.7
Tetrachloroethene	-	-	20.0	-	-	-	8.0
Total Petroleum Hydrocarbons	-	-	-	-	-	-	-

Legend

- 1 - National Interim Primary Drinking Water Standards; USEPA 40 CFR 141.
- 2 - National Secondary Drinking Water Standards; USEPA 40 CFR 143.
- 3 - Recommended Maximum Contaminant Levels; USEPA 40 CFR 141.
- 4 - USEPA Suggested No Adverse Response Levels.
- 5 - Preliminary Protective Concentration Limits for 40 CFR 261 Appendix VIII "Hazardous Constituents" where:
 - AD1 = Acceptable Daily Intake
 - MCL = Maximum Concentration Level
 - UCR = Unit Cancer Risk

(CL50228/4)

TABLE IV-18 (Continued)

AVAILABLE FEDERAL AND STATE WATER QUALITY CRITERIA FOR CONSTITUENTS DETECTED IN WATER SAMPLES
MINOT AIR FORCE BASE, MINOT, NORTH DAKOTA

- 6 - North Dakota Water Quality Standards; North Dakota Department of Health Rule 33-16-02, Section 06. (Class 1 - Streams)
7 - USEPA Ambient Water Quality Criteria; Federal Register, Vol. 45, No. 231, 11/28/80.
a - Proposed MCL, Federal Register Vol. 50, No. 261, 11/13/85, pg. 46930.
b - Proposed RMCL, Federal Register, Vol. 50, No. 261, 11/13/85, pg. 47022.
c - SWARL set for chronic exposure response.
- No standard established.

TABLE IV-19

COMPARISON OF SLA SURFACE WATER SAMPLING RESULTS WITH
AVAILABLE FEDERAL AND STATE WATER QUALITY CRITERIA

<u>Detected Constituent</u>	<u>Range of Concentrations</u> <u>mg/l</u>	<u>NIPDWSS¹</u> <u>mg/l</u>	<u>NSDWSS²</u> <u>mg/l</u>	<u>RMCLs³</u> <u>mg/l</u>	<u>PPCLs⁴</u> <u>mg/l</u>	<u>NDWQSS⁵</u> <u>mg/l</u>	<u>EPAAWQC⁶</u> <u>mg/l</u>
Priority Pollutant Metals							
Copper	BDL-0.04	-	1.0	1.30 ^a	-	0.05	1.0
Nickel	BDL-0.097	-	-	0.75(ADI); 0.00003(UCR)	-	-	0.0134
Zinc	0.03-0.22	-	5.0	7.5(ADI)	1.0	5.0	
Common Anions							
Chloride	50-400	-	250	-	-	100	-
Fluoride	1.3-1.6	2.0	-	-	-	-	-
Bromide	1.8-311	-	-	-	-	-	-
Nitrate	0.21-1.05	10.0	-	10.0 ^a	-	1.0	-
Nitrite	BDL-0.1	-	-	1.0 ^a	-	-	-
Phosphate	BDL-0.96	-	250	-	-	0.1	-
Sulfate	1100-3500	-	-	-	-	250	-
Total Dissolved Solids	2596-4782	-	500	-	-	-	-

Legend

- 1 - National Interim Primary Drinking Water Standards; USEPA 40CFR141.
 - 2 - National Secondary Drinking Water Standards; USEPA 40CFR143.
 - 3 - Recommended Maximum Contaminant Levels; USEPA 40CFR141.
 - 4 - Preliminary Protective Concentration Limits for 40CFR261, Appendix VIII "Hazardous Constituents" where:
 - ADI = Acceptable Daily Intake
 - MCL = Maximum Concentration Level
 - UCR = Unit Cancer Risk
 - 5 - North Dakota Water Quality Standards; North Dakota Department of Health Rule 33-16-02, Section 06.
 - 6 - USEPA Ambient Water Quality Criteria; Federal Register, Vol. 45, No. 231, 11/28/80.
 - a - Proposed RMCLs, Federal Register, Vol. 50, No. 261, 11/13/85, pg. 47022.
 - No standard established.
 - BDL - Below Detection Level.
- (CL5022B/4)

TABLE IV-20

COMPARISON OF SLA GROUND WATER SAMPLING RESULTS WITH
AVAILABLE FEDERAL AND STATE WATER QUALITY CRITERIA

<u>Detected Constituent</u>	<u>Range of Concentrations</u> mg/l	<u>NIDPSS¹</u> mg/l	<u>NSDSS²</u> mg/l	<u>RMCL³</u> mg/l	<u>PPCL⁴</u> mg/l	<u>NDASS⁵</u> mg/l	<u>EPARAC⁶</u> mg/l
Priority Pollutant Metals							
Copper	BDL-0.59	-	1.0	1.30 ^a	-	0.05	1.0
Nickel	BDL-0.43	-	-	0.75(AD1);0.00003(UCR)	-	0.0134	-
Lead	BDL-0.17	0.05	-	0.02 ^a	0.15(AD1);0.05(UCR)	0.05	0.05
Zinc	0.02-1.67	-	2.0	-	7.5(AD1)	1.0	5.0
Silver	BDL-0.02	0.05	-	0.05(MCL)	-	0.05	-
Common Anions							
Chloride	10-150	-	250	-	-	100	-
Flouride	0.38-1.20	2.0	-	-	-	-	-
Bromide	BDL-4.3	-	-	-	-	-	-
Nitrate	BDL-2.20	10.0	-	10.0 ^a	-	1.0	-
Phosphate	BDL-19.2	-	-	-	-	0.1	-
Sulfate	700-6300	-	250	-	-	250	-
Total Dissolved Solids	1280-9440	-	500	-	-	-	-
Total Petroleum Hydrocarbons	0.80	-	-	-	-	-	-

Legend

1 - National Interim Primary Drinking Water Standards; USEPA 40 CFR 141.

2 - National Secondary Drinking Water Standards; USEPA 40 CFR 143.

3 - Recommended Maximum Contaminant Levels; USEPA 40 CFR 141.

4 - Preliminary Protective Concentration Limits for 40 CFR 261, Appendix VIII "Hazardous Constituents" where:
ADI = Acceptable Daily Intake

MCL = Maximum Concentration Level

UCR = Unit Cancer Risk

5 - North Dakota Water Quality Standards; North Dakota Department of Health Rule 33-16-02, Section 06.

6 - USEPA Ambient Water Quality Criteria; Federal Register, Vol. 45, No. 231, 11/28/80.

a - Proposed RMCLs, Federal Register, Vol. 50, No. 261, 11/13/85, pg. 47022.

- No standard established.

BDL - Below Detection Level.

TABLE IV-21

COMPARISON OF FTA GROUND WATER SAMPLING RESULTS WITH
AVAILABLE FEDERAL AND STATE WATER QUALITY CRITERIA

Detected Constituent	Range of Concentration mg/l	NIPOMSS ¹ mg/l	RMCL ² mg/l	PPCL ³ mg/l	EPA DWA ⁴ mg/l	SNARL ⁵ mg/l	EPA AMAR ⁶ mg/l
Halogenated Volatile Organics							
1,2-Dichloroethane	BDL-0.011	5.0-0.005 ^a	0.0	0.0005(UCR); 0.00055(UCR)	0.740 (1-day, 10-day + chronic)	-	0.0005 ^a
1,1,1-Trichloroethane	BDL-0.011	0.20 ^a	0.20	19.0(AD1); 0.022(UCR)	140.0 (1-day); 35 (10-day + chronic)	1.0 ^b	18.4
Bromo-dichloroethane	BDL-0.0033	0.10	-	0.019(AD1)	-	-	0.00019
Trichloroethene	BDL-0.004	0.005 ^a	-	-	-	-	0.0027
Tetrachloroethene	BDL-0.002	-	-	-	34.0 (10-day); 1.9% (chronic)	-	0.0008
Total Petroleum Hydrocarbons	BDL-0.50	-	-	-	-	-	-

Legend

- 1 - National Interim Primary Drinking Water Standards; USEPA 40 CFR 141.
 - 2 - Recommended Maximum Contaminant Level; USEPA 40 CFR 141.
 - 3 - Preliminary Protective Concentration Level for 40 CFR 261, Appendix VIII "Hazardous Constituents" Where:
- ADI = Acceptable Daily Intake
 MCL = Maximum Concentration Level
 UCR = Unit Cancer Risk
- 4 - EPA Drinking Water Health Advisories for a 10 kg infant
 - 5 - USEPA Suggested No Adverse Response Levels.
 - 6 - USEPA Ambient Water Quality Criteria; Federal Register, Vol. 45, No. 231, 11/28/80.
- a - Proposed MCL, Federal Register, Vol. 50, No. 261, 11/13/85, pg. 47022.
 b - SNARL Set for Chronic Exposure Response.
 - No Standard Established.

Comparison of MCLs with the results of surface water and ground water sampling and analyses indicated that one parameter has been detected in concentrations which exceed NIPDWS. The MCL for lead is 0.05 mg/l. Lead was detected in SLA ground water samples obtained from DW-2 and MW-4 in concentrations of 0.15 and 0.17 mg/l, respectively (Tables IV-20 and IV-6).

Also pursuant to Section 1412 of the SDWA, EPA has promulgated "National Secondary Drinking Water Standards" (NSDWS). These standards control contaminants in drinking water that primarily affect the aesthetic quality relating to the public acceptance of drinking water. At considerably higher concentrations of these contaminants, health implications may also exist as well as aesthetic degradation. These standards are not federally enforceable but are intended as guidelines for the states. The State of North Dakota has not adopted NSDWS because it recognizes that natural mineralization of ground water within the state may result in these standards being exceeded.

Despite the fact that North Dakota does not recognize NSDWS, it is useful to compare the results of surface water and ground water sample analyses to these standards to make a determination of overall aesthetic water quality. This comparison indicated that SLA surface water samples contained chloride, sulfate and TDS in concentrations exceeding NSDWS (Tables IV-3 and IV-19) and that SLA ground water samples contained sulfate and TDS in concentrations exceeding NSDWS (Tables IV-6 and IV-20). The NSDWS for chloride, sulfate and TDS are 250, 250 and 500 mg/l, respectively. The detected concentrations of chloride in SLA surface water ranged from 50 to 400 mg/l and averaged 226 mg/l. The detected concentrations of sulfate in SLA surface water ranged from 1,100 to 3,500 mg/l and averaged 2,540 mg/l. The detected concentrations of TDS in SLA surface water ranged from 2,596 to 4,782 mg/l and averaged 4,095 mg/l. The detected concentrations of sulfate in SLA ground water ranged from 700 to 6,300 mg/l and averaged 2,934 mg/l. The detected concentration of TDS in SLA ground water ranged from 1,280 to 9,440 mg/l and averaged 3,880 mg/l.

(CL5142A/1)

Pursuant to Section 1412(b)(1)(B) of the SDWA, EPA has promulgated "Recommended Maximum Contaminant Levels" (RMCLs). These levels are based upon a report from the National Academy of Sciences and set target levels for contaminants in drinking water that have no known or anticipated adverse effects on human health and allow for an adequate margin of safety. RMCLs do not take treatment costs and other feasibility factors into consideration; RMCLs are not federally enforceable standards.

Comparison of RMCLs with the results of surface water and ground water sample analyses indicated that lead is present in two SLA ground water samples in concentrations which exceed the RMCL. The RMCL for lead is 0.02 mg/l. Lead was detected in SLA ground water samples obtained from DW-2 and MW-4 in concentrations of 0.15 and 0.17 mg/l, respectively (Tables IV-6 and IV-20).

EPA has also established "Suggested No Adverse Response Levels" (SNARLs) for unregulated drinking water contaminants commonly found in potable water supplies. The SNARLs recommend concentration levels in drinking water at or below which no adverse health effects would be anticipated. SNARLs are not federally enforceable.

Of the 19 parameters detected in ADL concentrations in surface and ground water samples, only 1,1,1-trichloroethane has an established SNARL, which is 1.0 mg/l. 1,1,1-trichloroethane was detected in the FTA ground water sample obtained from SW-9 in a concentration of 0.011 mg/l which is below the established SNARL for 1,1,1-trichloroethane.

An EPA compilation of agency reviewed health effects data for some of the 40 CFR 261 Appendix VIII "Hazardous Constituents" has provided "Preliminary Protective Concentration Limits" (PPCLs). PPCLs refer to suggested exposure limits at the point of consumption. These values assume exposure of a 70 kg (154 lb) adult consuming two liters of water per day. Specified PPCLs are based upon one of the following justifications: acceptable daily intake (ADL), unit cancer risk (UCR) or maximum contaminant level (MCL). The PPCL values and justifications are (CL5142A/1)

derived from data obtained from one of ten source documents published by the USEPA (see Appendix J). The PPCLs based on UCRs correspond to an incremental increase in cancer risk of 10^{-6} . PPCLs are not federally enforceable.

Commonly, more than one PPCL is specified for a given constituent based upon different justifications or different source documents. PPCLs for individual constituents often differ by more than one order of magnitude. PPCLs are presented in this report as a qualitative indication of the dangers associated with the individual constituent.

The State of North Dakota has promulgated water quality criteria for designated types of surface water bodies. The "North Dakota Water Quality Standards" (NDWQS) are established under the North Dakota State Department of Health (DOH) Rule 33-16-02. North Dakota surface water quality standards and conditions are contained in Tables IV-22 and IV-23, respectively. Specific quality standards for designated classes of water are provided in Section 06, stream classification is provided in Section 08 and lake classification is provided in Section 09 of DOH rule 33-16-02. Specific standards are prescribed for designated classes of water to protect their beneficial uses as set forth in the water use description and classification. The most stringent standards are set for Class I streams and classified lakes. These standards are shown in Tables IV-19, IV-20 and IV-21 for detected constituents.

A direct comparison of the results of surface water and ground water sample analyses is not useful because ground water does not discharge to surface water at MAFB and surface water at MAFB is unclassified. The standards are shown on Chapter IV tables for qualitative comparison purposes.

Pursuant to Section 304(a)(1) of the Clean Water Act, EPA has promulgated Ambient Water Quality Criteria (EPAAWQC). These criteria present quantitative concentrations or qualitative assessments of the pollutants in water which will generally ensure water quality adequate to support a specified water use. These criteria are based solely on (CL5142A/1)

TABLE IV-22

NORTH DAKOTA GENERAL SURFACE WATER QUALITY STANDARDS;
NORTH DAKOTA DEPARTMENT OF HEALTH RULE 33-16-02, SECTION 06

<u>Parameter</u>	<u>Classified Lakes and Class I Streams</u>			<u>Limitations</u>		
	<u>Class I Streams</u>	<u>Class IA Streams</u>	<u>Class II Streams</u>	<u>Class III Streams</u>	<u>Units</u>	
Ammonia ¹	0.02	0.02	0.02	0.1	mg/l	
Arsenic (Total)	0.05	0.05	0.05	0.1	mg/l	
Barium (Dissolved)	1.0	1.0	1.0	1.0	mg/l	
Boron (Dissolved)	0.75	0.75	0.75	0.75	mg/l	
Cadmium (Total)	0.01	0.01	0.01	0.01	mg/l	
Chlorides	100*	175**	250**	250**	mg/l	
Chromium (Total)	0.05	0.05	0.05	0.05	mg/l	
Copper (Total)	0.05	0.05	0.1	0.1	mg/l	
Cyanides (Total)	0.005	0.005	0.005	0.1	mg/l	
Lead (Dissolved)	0.05	0.05	0.05	0.05	mg/l	
Nitrates (Dissolved)	1.0	1.0	1.0	1.0	mg/l	
Phosphates (Dissolved)	0.1	0.1	0.1	0.1	mg/l	
Zinc (Total)	1.0	1.0	1.0	1.0	mg/l	
Selenium (Total)	0.01	0.01	0.01	0.01	mg/l	
Polychlorinated Biphenols (Total)	0.15	0.15	0.15	0.15	ug/l	
Dissolved Oxygen	>5.0	>5.0	>5.0	>5.0	mg/l	
Sodium	50% of Total	60% of Total	60% of Total	60% of Total	-	
Phenols	Cations	Cations	Cations	Cations	-	
Sulfates (Dissolved)	250	0.01	0.01	0.01	mg/l	
Chlorine (Total Residual)	0.2	0.2	0.2	0.2	mg/l	
Mercury (Total)	0.002	0.002	0.002	0.002	mg/l	
pH	7.0-8.5	7.0-8.5	6.0-9.0	6.0-9.0	pH Units	
Temperature ²	85	85	85	85	°F	

Legend

1 - For any discharge continuing beyond 20 days.
 2 - Maximum increase shall not be greater than 5°F above background conditions.

* Total

** Dissolved

(CL5022B/4)

TABLE IV-23

NORTH DAKOTA GENERAL SURFACE WATER QUALITY CONDITIONS¹
NORTH DAKOTA DEPARTMENT OF HEALTH RULE 33-16-02, SECTION 05

All waters of the state shall be:

- o Free from substances attributable to municipal, industrial, or other discharges or agricultural practices that will cause the formation of putrescent or otherwise objectionable sludge deposits.
- o Free from oil or grease residue attributable to wastewater, which causes a visible film or sheen upon the waters or any discoloration of the surface of adjoining shoreline or causes a sludge or emulsion to be deposited beneath the surface of the water or upon the adjoining shorelines or prevents classified uses of such waters.
- o Free from materials attributable to municipal, industrial, or other discharges or agricultural practices producing color, odor, or other conditions in such a degree as to create a nuisance or render any undesirable taste to fish flesh, or in any way, make fish inedible.
- o Free from substances attributable to municipal, industrial, or other discharges or agricultural practices in concentrations or combinations which are toxic or harmful to human, animal, plant, or resident aquatic biota.
- o Free from floating debris, oil, scum, and other floating materials attributable to municipal, industrial, or other discharges or agricultural practices in sufficient amount to be unsightly or deleterious.
- o There shall be no materials such as garbage, rubbish, trash, cans, bottles, or any unwanted or discarded material disposed of into the waters of the state.

1- These water quality conditions are applicable to all waters in North Dakota, in all places, at all times regardless of classification; unclassified waters included.

scientific data and scientific judgments on the relationship between pollutant concentrations and environmental and human health effects. These criteria have no regulatory impact. Rather, these criteria present scientific data and guidance on the environmental effect of pollutants which can be useful in deriving regulatory requirements based on considerations of water quality impact.

Comparison of Ambient Water Quality Criteria with the results of surface water and ground water sampling and analyses indicate that nickel, lead, 1,2-dichloroethane and bromodichloromethane were detected in concentrations which exceed these criteria.

D.4 The Sanitary Landfill Area: Significance of Findings

This section contains discussions on the significance of laboratory analyses results for samples obtained during the HART investigation of the SLA, and in particular the significance of constituents detected in surface water and ground water samples. In the Phase I study it was determined that a wide variety of materials may have been disposed of in the MAFB sanitary landfill; therefore, in order to fully evaluate the potential existence of contamination, a wide variety of laboratory analyses were conducted on SLA surface water and ground water samples. These analyses included aromatic and halogenated volatile organic compounds, acid and base/neutral extractable priority pollutant organic compounds, TPH, TDS, common anions and 13 priority pollutant metals (PP metals). Fourteen ground water and five surface water samples, including a duplicate from each group, were laboratory analyzed.

The results of the sample analyses (Tables IV-2, IV-3, IV-5 and IV-6) indicate that surface water and ground water within the SLA contained the following constituents in ADL concentrations in at least one sample: copper, nickel, zinc, lead, silver, chloride, fluoride, bromide, nitrate, nitrite, phosphate, sulfate and total petroleum hydrocarbons.

Measurements of pH obtained in the field during ground water sampling (Table IV-6) indicate that the pH of nine ground water samples obtained from the SLA (012, 004, 005, 006, 013, 014, 017, 019 and 020) exceeded 9, which is commonly accepted as the upper limit of the range of pH in natural environments. Calibration procedures for the pH meter are presented in Appendix F.2. Although calibration of the pH meter was performed daily, it appears likely from the pH results for these nine ground water samples that the pH meter was malfunctioning during ground water sampling. The pH measurements obtained during well development (Table IV-3) probably provide a more accurate representation of the actual conditions at each well location.

With the exception of petroleum hydrocarbons, all of the constituents detected in SLA surface water and ground water samples are substances which commonly occur naturally in water. For this reason, their presence does not necessarily indicate the existence of contamination. The North Dakota State Department of Health has not adopted federal secondary drinking water standards which have been established for copper, zinc, chloride, sulfate and TDS because the state has recognized that natural mineralization of ground water within the state may, and commonly does, result in concentrations of these substances which exceed established standards. Thus, elevated concentrations of some of the constituents detected in SLA surface water and ground water samples do not necessarily indicate the existence of contamination.

The Technical Operations Plan (Appendix L), which the HART investigation of the SLA was based upon, did not include background surface water or ground water quality sampling. Thus, no site specific background water quality data is available for the MAFB/SLA investigation. Therefore, for comparison purposes only, background water quality will be extrapolated from several different sources.

Pettyjohn and Hills (1965) completed a study entitled "Geohydrology of the Souris River Valley in the Vicinity of Minot, North Dakota." Comeskey and Reiten (1982) completed a study entitled "Ground Water Resources of the Surry Area, Ward County, North Dakota." Both of these studies (CL5142A/1)

involved sampling and chemical analyses of ground water samples (Table II-1). However, the results of these analyses cannot be directly compared to the analyses results of samples taken during the SLA investigation for several reasons. The ground water samples from the SLA investigation were obtained from discontinuous sand and gravel deposits that averaged only 2 ft in thickness and rarely exceeded 4 ft in thickness. These sand and gravel deposits are also very limited in areal extent. Thus, the ground water samples from the Pettyjohn and Hills (1965) study and the Comeskey and Reiten (1982) study were obtained from sand and gravel deposits which are estimated to be more than 50 times greater in size than any sand and gravel deposit encountered at MAFB.

Ground water contained within the larger sand and gravel aquifers experiences greater circulation and less contact with the glacial till. In places, these sand and gravel aquifers are exposed at the surface allowing meteoric water to enter the aquifer without any contact with the glacial till. In contrast, the sand and gravel deposits encountered at MAFB experience very little ground water circulation. Also, the ground water obtained from these deposits is likely to have had extensive contact with the glacial till. It is reasonable to assume that the low circulation and extensive contact with the glacial till are the major contributing factors to the high degree of ground water mineralization encountered at MAFB (Lindwig, 1987). Milton Lindwig of the North Dakota State Water Commission has confirmed the fact (personnel communication) that the concentrations of constituents detected in MAFB/SLA ground water samples are not unusual given the type of deposits from which these samples were obtained.

The Pettyjohn and Hills (1965) study also involved the chemical analyses of surface water samples taken near MAFB. The results of these analyses are shown in Table IV-24. However, the surface water bodies from which these samples were taken are likely to experience a greater degree of circulation than surface water contained within the SLA; thus, the concentrations of certain constituents is likely to be much lower in the Pettyjohn and Hills (1965) study samples than the concentrations of the same constituents in SLA surface water samples.

IV-89
TABLE IV-24

CHEMICAL ANALYSES OF SURFACE WATER
IN THE VICINITY OF MINOT, NORTH DAKOTA
(All results in mg/l)

<u>Sample</u>	<u>Sulfate</u>	<u>Nitrate</u>	<u>Chloride</u>	<u>TDS</u>
1	72.0	50.0	20.0	425.0
2	259.0	8.0	27.0	863.0
3	214.0	5.0	31.0	738.0

Legend

Sample Locations

- 1 - Sample collected from an oxbow lake in Oak Park, Minot, North Dakota.
- 2 - Sample collected from an experimental recharge pit in Oak Park, Minot, North Dakota.
- 3 - Sample collected from the Souris River in Oak Park, Minot, North Dakota.

Source: Pettyjohn and Hills, 1965

(CL5022B/4)

Surface water within the SLA is essentially contained within this area. The unfilled landfill trenches, which have accumulated surface water and account for the greatest volume of SLA surface water, either do not discharge or discharge very little to the SLA drainage ditch. Water accumulating within these trenches from precipitation is assumed to either percolate into the ground or evaporate. Given the impermeability of the till sediments underlying the area and the semi-arid to sub-humid climate, it is reasonable to assume that evaporation is responsible for the greatest reduction in the volume of surface water within these trenches.

The SLA drainage ditch is a poorly defined trench that contains water only in small depressions. It is believed that water fills the ditch only during times of heavy precipitation, which probably amounts to a few weeks out of the year. It is also believed that, even during times of heavy precipitation, no significant flow occurs within this drainage ditch; instead, water accumulates in ponds and is eventually removed by infiltration and evaporation. In the event that water did flow within this ditch, it would flow east out of the SLA, merge with a drainage ditch emanating from the southwest portion of the base and then flow northeast until it merges with Egg Creek near the northeast corner of the base. Egg Creek is an unclassified, intermittent stream that, from the point of confluence with the MAFB drainage ditches, continues several miles southeast until it joins with the Souris River.

The SLA surface water samples contained all the common anions in ADL concentrations. Chloride, nitrate, phosphate and sulfate were the only common anions present in concentrations which exceeded established water quality criteria. These anions were present in concentrations which exceeded North Dakota Water Quality Standards for surface water. Chloride and sulfate were present in concentrations which exceeded National Secondary Drinking Water Standards. Comparison of detected concentrations of these anions with the background water quality data (Table IV-24) indicates that nitrate is below background levels and sulfate and chloride are above background levels for these constituents.

SLA surface water contained the priority pollutant metals copper, nickel and zinc in ADL concentrations. Nickel was the only metal present in concentrations which exceeded an established criteria. Nickel was detected in 4 surface water samples in concentrations which exceeded EPA Ambient Water Quality Criteria.

The elevated concentrations of sulfate, chloride and nickel in SLA surface water are believed to be the result of two processes. First, SLA surface water is mineralized through contact with the weathered, surficial glacial till sediments. Second, evaporation of surface water results in the concentration of these constituents in surface water bodies.

The SLA surface water as well as all MAFB surface water and Egg Creek are unclassified water bodies. According to NDWQS, no specific water quality standards are set for unclassified surface water bodies and the quality of water in these surface water bodies is governed only by the general conditions provided in Section 05 of DOH Rule 33-16-02 (Table IV-23). Thus, the presence of high concentrations of sulfate, chloride and nickel in SLA surface water does not constitute noncompliance with any enforceable federal or state standards. In addition, the unlikely possibility that SLA surface water migrates into any other MAFB drainage ditch or Egg Creek would also not constitute noncompliance with any enforceable federal or state standard.

The elevated concentrations of all SLA ground water constituents, except petroleum hydrocarbons, are believed to be the result of mineralization of the ground water through contact with glacial till sediments. Petroleum hydrocarbons were only detected in one ground water sample in a very low concentration. For this reason, it is very difficult to determine if the presence of petroleum hydrocarbons in ground water sample 021 represents significant contamination.

As discussed in this and other chapters, ground water at MAFB appears to migrate downward at the rate of approximately a few centimeters per year or one foot per 10 years. Based on the fact that there are no significant water bearing units within the glacial sediments within a five (CL5142A/1)

mile radius of MAFB and bedrock is known to be at a depth of at least 100 ft, it is reasonable to assume that the potential for contamination of a water supply by ground water emanating from the SLA is minimal. In addition, there are no points of ground water discharge within a five mile radius of MAFB; thus, the potential for human exposure to SLA ground water is also minimal.

D.5 FTA: Significance of Findings

A discussion of the significance of constituents detected in ground water, subsurface soil and surface sediment samples from the FTA follows. The Phase I study conducted at MAFB indicated that a variety of oils, solvents, fuels and lubricants may be present in the FTA as environmental contaminants. Thus, the analyses performed on samples taken in the FTA included TPH, aromatic volatile organic (AVO) compounds, halogenated volatile organic (HVO) compounds and lead. The results of sample analyses (Tables IV-8, IV-10 and IV-12) indicate that FTA ground water contained HVOs and TPH in ADL concentrations and FTA subsurface soil and surface sediment contained AVOs, TPH and lead in ADL concentrations.

D.5.a Extent of Contamination. Two ground water monitoring wells were installed in the FTA to determine the hydrostatic properties of the subsurface sediments and to determine the water quality of the ground water in this area. One ground water sample was obtained from each well and a duplicate sample was obtained from SW-9.

The ground water sample obtained from SW-8 contained no AVOs, HVOs, TPH or lead. Neither of the samples obtained from SW-9 contained any AVOs or lead. One sample from SW-9 contained TPH in a concentration equal to the detection limit (0.5 mg/l) and did not contain HVOs; the second sample from SW-9 contained no TPH but did contain five compounds classified as HVOs in concentrations ranging from 0.002 to 0.011 mg/l. The presence of these compounds were verified by duplicate analyses. The detection limits for these HVO compounds varied from 0.001 to 0.002 mg/l.

No water quality criteria are available for TPH. The RMCL and SNARL for 1,1,1-trichloroethane are 0.20 and 1.0 mg/l, respectively; these levels are one and two orders of magnitude, respectively, above the detected concentration of 1,1,1-trichloroethane in the FTA ground water sample obtained from SW-9. The NIPDWS for total halomethanes, of which bromodichloromethane is a constituent, is 0.10 mg/l. The detected concentration of bromodichloromethane in FTA ground water sample SW-9 was 0.003 mg/l, which is three orders of magnitude below the NIPDWS. No other applicable and enforceable water quality criteria are available for the HVO compounds detected in the FTA ground water sample obtained from SW-9.

Two important conclusions can be made regarding the constituents detected in FTA ground water. First, no constituents were detected in FTA ground water which exceeded any applicable and enforceable water quality criteria. Second, where water quality criteria were available, the detected concentrations of constituents in FTA ground water were at least one order of magnitude below the established criteria. Thus, on the basis of all available information, it is reasonable to conclude that the samples obtained from FTA ground water were not significantly contaminated with respect to the parameters analyzed. However, due to the discontinuous nature of the water bearing sand and gravel deposits encountered at MAFB, it is not possible to state, based on the information presently available, that no significant contamination of FTA ground water has occurred.

A single test boring (TB-1) was completed in the center of the FTA to obtain subsurface soil samples for chemical analyses. Four samples were sent for analyses. Sampling procedures and all other sampling information is contained in Chapter III of this report. A PTL QC data review is provided in Section C of this chapter. The results of analyses indicate the following: 1) TPH was found in all samples in ADL concentrations ranging from 13 to 780 mg/kg; 2) no HVO compounds were found in ADL concentrations in any of the samples; 3) lead was found in all samples in ADL concentrations ranging from 2.34 to 4.28 mg/kg; and 4) all of the AVO compounds except benzene were found in ADL concentrations ranging from 0.30 to 3.80 mg/kg. The presence of AVO compounds in subsurface soil samples was verified by confirmatory analyses.

Table IV-25 shows the typical trace element content of natural soils. The common range of lead in natural soils is 2 to 200 parts per million (ppm) and the average is 10 ppm (ppm are approximately equivalent to mg/kg). The detected concentrations of lead in FTA subsurface soil samples, ranging from 2.34 to 4.28 mg/kg, are within the common range and are below the average. No data is available on the trace element content of soils native to the MAFB area. From the background data which is available, there is no indication that the detected concentrations of lead in FTA subsurface soil samples indicates contamination.

AVO compounds and petroleum hydrocarbons are not naturally occurring substances in soils and, thus, comparison to background levels is not possible. In addition, no soil quality criteria have been established for these soil contaminants. Thus, it is only possible to state on a qualitative basis that some contamination of subsurface soil at the FTA exists with respect to the parameters AVOs and TPH.

It is not possible to make accurate determinations regarding the horizontal and vertical distribution of contaminants in FTA subsurface soil from information obtained from a single test boring. It appears that contamination of subsurface soil at the location of the test boring (TB-1) is significantly reduced beyond the depth of 17 ft. The subsurface soil sample obtained from the 15 to 17 ft interval contained total petroleum hydrocarbons with a concentration of 290 mg/kg and AVO compounds with concentrations ranging from 0.45 to 3.80 mg/kg. The subsurface soil sample obtained from the 20 to 22 ft interval contained petroleum hydrocarbons in a concentration of 13 mg/kg and did not contain any detectable AVO compounds. Although it appears as though a significant decrease in contamination does occur beyond the 15 to 17 ft interval, it is not possible to determine if this interval represents a point of significant decrease in contamination throughout the FTA.

Surface sediment samples were obtained from three locations in the FTA drainage ditch for chemical analyses. Four samples were sent for chemical analyses. The results of analyses (Table IV-12) indicate the following: 1) petroleum hydrocarbons were found in all samples in ADL concentrations (CL5142A/1)

IV-95
TABLE IV-25

TRACE CHEMICAL ELEMENT CONTENT OF NATURAL SOILS

<u>Element</u>	<u>Common Range (ppm)</u>	<u>Average (ppm)</u>	<u>Element</u>	<u>Common Range (ppm)</u>	<u>Average (ppm)</u>
Aluminum	10,000-300,000	71,000	Lithium	5-200	20
Antimony	2-10	-	Magnesium	600-6,000	5,000
Arsenic	1-50	5	Manganese	20-3,000	600
Barium	100-3,000	430	Mercury	0.01-0.3	.03
Beryllium	0.1-40	6	Molybdenum	0.2-5	2
Boron	2-100	10	Nickel	5-500	40
Bromine	1-10	5	Radium	8×10^{-5}	-
Cadmium	0.01-0.7	.06	Rubidium	50-500	10
Cesium	0.3-25	6	Selenium	0.1-2	.3
Chlorine	20-900	100	Silver	0.01-5	.05
Chromium	1-1,000	100	Strontium	50-1,000	200
Cobalt	1-40	8	Tin	2-200	10
Copper	2-100	30	Tungsten	-	1
Fluorine	10-4,000	200	Uranium	0.9-9	1
Gallium	0.4-300	30	Vanadium	20-500	100
Gold	-	1	Yttrium	25-250	50
Iodine	0.1-40	5	Zinc	10-300	50
Lanthanum	1-5,000	30	Zirconium	60-2,000	300
Lead	2-200	10			

REF: USEPA Office of Solid Waste & Emergency Response, HAZARDOUS WASTE LAND TREATMENT, SW-874 (April, 1983) Page 273, Table 6.46.

(CL5022B/4)

ranging from 350 to 16,550 mg/kg; 2) lead was found in ADL concentrations in all samples ranging from 1.33 to 12.20 mg/kg; 3) no HVO compounds were detected in ADL concentrations; and 4) all of the AVO compounds were found in ADL concentrations ranging from 0.1 mg/kg to 12.0 mg/kg.

The detected concentrations of lead in FTA surface sediment samples are within the common range of lead in natural soils (Table IV-25). The detected concentrations are also very similar to the average concentration of lead in natural soils. Although no background data is available on the trace element content of sediments in the MAFB area, there is no indication that the detected concentration of lead in FTA surface sediment samples indicates contamination.

As stated previously, it is not possible to compare detected AVO or TPH concentrations in surface sediment samples to background or to established quality criteria; thus, it is only possible to state on a qualitative basis that some contamination of surface sediment within the FTA drainage ditch exists with respect to the parameters AVO and TPH.

It is not possible to make accurate determinations regarding the vertical and lateral distribution of contaminants based upon the limited sampling conducted within the FTA drainage ditch. Review of available data does indicate, however, that contamination decreases significantly beyond sample site SD-2. Sediment samples taken from sample sites SD-1 and SD-2 contain TPH in concentrations ranging from 3,230 to 16,550 mg/kg and AVO compounds in concentrations ranging from 0.1 to 12.0 mg/kg. The sediment sample taken at sample site SD-3 contained TPH with a concentration of 350 mg/kg and did not contain any AVO compounds. Although the lateral extent of contamination has been determined to a limited extent, determination of the vertical distribution of contaminants is not possible as sampling was limited to depths of 0 to 12 inches.

D.5.b Evaluation of Contamination. The contaminants identified within the FTA include AVO compounds and TPH detected in subsurface soil and surface sediment samples. Given the fact that the FTA served as a contaminated fuel and lubricant disposal point for many years and that (CL5142A/1)

approximately 2,000 gallons of JP-4 fuel are burned each month in training operations, it is reasonable to attribute the presence of these contaminants to activities related to the FTA. In addition, a firefighting training operation was conducted during the period of the HART investigation during which HART personnel observed and noted spent fuel and extinguishing materials flowing from the burn pit through the oil/water separator and into the drainage ditch. Apparently, the oil/water separator is ineffective in its purpose. Thus, it is reasonable to attribute the presence of the contaminants within the drainage ditch to activities related to the FTA.

Noted health effects of FTA contaminants are shown in Table IV-26. The risk of human exposure to these contaminants ranges from low to moderate.

The contaminants present in FTA subsurface soil are essentially immobile. As previously demonstrated, the permeability of the glacial till underlying MAFB is very low and the vertical component of ground water movement is downward at the approximate rate of one foot per 10 years. Although higher concentrations than those detected in the ground water sample obtained from SW-9 of the FTA contaminants may exist, the ground water migration rate is significantly low enough to prevent widespread contamination. Moreover, the rate of organic contaminant migration through FTA soils can be expected to be lower than ground water migration due to natural processes such as volatilization, attenuation and adsorption onto soil particles and biodegradation. No significant water bearing sand and gravel units are known to exist within the glacial sediments within five miles of MAFB and bedrock is known to be at a depth of at least 100 ft. Thus, the potential for contamination of a water supply by FTA contaminants is minor. The potential for human exposure to contaminated subsurface soil or ground water is also minor.

TABLE IV-26

HEALTH EFFECTS OF FTA CONTAMINANTS

<u>Contaminant</u>	<u>Health Effect</u>
Toluene	• Mutagen data; experimental equivocal tumorigenic agent; teratogenic effects; carcinogenic effects.
Benzene	• Experimental mutagen; carcinogenic and teratogenic effects; equivocal tumorigenic agent; neoplastic effects.
Ethylbenzene	• Experimental teratogenic effects; skin, eyes and mucous membrane irritant.
1,4-Dichlorobenzene	• Mutagen data; hepatotoxic; experimental carcinogenic.
1,3-Dichlorobenzene	• Less toxic than 1,2-Dichlorobenzene.
1,2-Dichlorobenzene	• Eye, skin and mucous membrane irritant; experimental + carcinogenic; hepatotoxic and nephrotoxic in experimental animals; high concentrations cause CNS depression.
Chlorobenzene	• Strong narcotic effect; slight irritant qualities; cyanosis.

Source: N. Irving Sax, Editor, Dangerous Properties of Industrial Materials, Sixth Edition, 1984.

The contaminants present within the FTA drainage ditch are essentially at the surface and thus the potential for human exposure exists. Human exposure could occur by contact with in-situ sediments or by contact with airborne particles.

The FTA drainage ditch is similar to the SLA drainage ditch in that it only contains water in small depressions throughout most of the year. During times of heavy precipitation, however, water does flow within this ditch. Flow in this ditch is north until it merges with the SLA drainage ditch and then northeast towards Egg Creek. The flow of water in this ditch creates the potential for both human exposure and contaminant migration. The overall potential for human exposure to FTA drainage ditch contaminated sediments is moderate.

D.6 The Explosive Ordnance Disposal Area: Significance of Findings

A discussion of the significance of constituents detected in subsurface soil samples from the EOD follows. In the Phase I study it was determined that a potential for heavy metal contamination existed in the EOD soils due to explosives disposal activities conducted within the EOD. In addition, as the EOD was used briefly by a construction contractor as a staging area, a potential for petroleum hydrocarbon contamination resulting from unreported fuel spills exists. A single test boring was completed in the center of the EOD. Three samples were sent for laboratory analyses for TPH and 13 priority pollutant metals (two samples plus a duplicate).

The results of the analyses indicate that total petroleum hydrocarbons are not present in ADL concentrations and that, of the 13 PP metals analyzed, cadmium, chromium, copper, nickel, lead, zinc, silver and mercury were present in ADL concentrations.

Comparison of the results of EOD subsurface soil chemical analyses (Table IV-13) to the trace element content of natural soils (Table IV-25) indicates the following: 1) the metals chromium, copper and nickel were present in concentrations which were below the average trace element content of natural soil; 2) cadmium concentrations exceeded the average trace element content and the common range in natural soil; and 3) lead, zinc, silver and mercury were present at levels that fall within the common range of each elements' content in natural soil.

No data is available on the trace element content of soil native to MAFB; thus, all interpretations must be based upon comparison with Table IV-25. This comparison indicated that the only metal detected in unusually high concentrations in EOD subsurface soil was cadmium. Cadmium concentrations may represent minor contamination of subsurface soil.

The potential for human exposure to potentially contaminated EOD soil is moderate. Human exposure could occur from direct contact with in-situ soil or exposure to airborne particulates.

V. ALTERNATIVE MEASURES

This section details all the major possible options by site, excluding mitigation and cleanup measures, but including monitoring actions. The major options to be considered for each site are further investigations, long-term monitoring and no action.

A. Alternatives For The Sanitary Landfill Area

Further investigation in the SLA would involve a second stage of the Phase II investigation. A second stage investigation could involve additional test borings and well installation, including a test boring to the depth of bedrock and a monitoring well in the lower portion of glacial sediments. A second stage investigation could also involve subsurface soil and surface sediment sampling and chemical analyses in addition to surface water and ground water sampling.

Long-term monitoring would consist of sampling the wells installed during HART's investigation and analyzing the samples for a reduced parameter list. Based on the constituents identified as potential contaminants in Chapter IV, a suite of parameters would be chosen to monitor for changes in ground water quality. Parameters that best characterize the present constituents found in the ground water and that could be indicators of contamination would include common anions and PP metals. Upon initiation of a ground water monitoring program, semi-annual sampling of the wells would be adequate for the SLA, due to its situation in a secure geologic unit and the fact that ground water from this area is not used for human consumption and is not hydraulically connected to any potable water supply.

A three-phase approach to monitoring is suitable for the SLA. First, all the HART-installed wells will be sampled semi-annually for two years. The second phase will begin if, after two years, statistically the ground water chemistry has stabilized or decreased for the above-mentioned analyses parameters. If these conditions are observed, the parameter list (CL5052A/13)

and the number of wells sampled will both be decreased. The final phase consists of annual sampling for a period of two years; if, after that time, statistically the ground water chemistry has stabilized or decreased for the reduced list of parameters, sampling will be discontinued. Based on the investigation conducted by HART, long-term ground water monitoring is the recommended alternative for the SLA.

A third alternative, the no action alternative, involves accepting the data currently available for the SLA without any additional investigation or monitoring.

B. Alternatives For The Firefighting Training Area

Aromatic volatile organic compounds and petroleum hydrocarbons were found in significant concentrations in FTA subsurface soil and in the FTA drainage ditch surface sediments. Relatively insignificant concentrations of halogenated volatile organics and petroleum hydrocarbons were detected in FTA ground water. The Phase II investigation conducted by HART was sufficient in identifying contaminants present in the FTA and FTA drainage ditch. However, this investigation was not sufficient in establishing a data base which will allow a comprehensive evaluation of the extent and magnitude of contamination of the FTA and FTA drainage ditch.

Further investigation of the FTA and FTA drainage ditch should be undertaken to assess the vertical and lateral extent of subsurface soil and surface sediment contamination. These investigations would require that a more extensive subsurface soil and surface sediment sampling and analyses program be conducted in this area. Further investigations would also be designed to delineate the vertical and lateral extent of any water-bearing sand and gravel deposits within the till underlying the FTA. Further investigation should also involve installation of additional monitoring wells in the FTA.

In addition to the further investigations necessary to determine the extent and magnitude of contamination, a long-term ground water monitoring program could be initiated for the FTA monitoring wells. Long-term ground water monitoring at the FTA should be performed on a semi-annual basis as in the SLA. The important indicators of contamination from this area would be TPH, aromatic and halogenated volatile organics and lead. As long as the FTA is being used in its present condition, ground water monitoring will be necessary to assess the likely increase in contamination. Monitoring of the effluent of the oil/water separator and maintenance of the oil/water separator is necessary to assure that contamination is not entering the FTA drainage ditch. In its present condition, the oil/water separator is entirely ineffective for this purpose.

Based on all currently available data relevant to the FTA, as discussed in Chapter IV, recommended alternatives include both further investigation and long-term monitoring. Based on the known presence of contaminants, the no action alternative, accepting the data as currently available, is not feasible at this time.

C. Alternatives For The Explosive Ordnance Disposal Area

The major possible alternatives available for the EOD are no action and further investigation. The subsurface results for the EOD indicate concentrations of cadmium exceeding the natural range found in soils. While this is not exceeding any established standards, to assure that there is no surface contamination, additional work at this site is recommended.

Further investigations necessary at the EOD would involve sampling the surface soils (0-6 inches). Samples analyzed in the HART investigation were subsurface soil samples. Due to the fact that munitions were destroyed at the surface of the EOD, surface soils would be the most likely place for metals contamination. Three grab samples are recommended for analyses for priority pollutant metals.

VI. RECOMMENDATIONS

The purpose of this chapter is to detail the recommended alternatives for each of the three areas of the Phase II investigation conducted by HART at MAFB. As discussed earlier, the scope of the Phase II investigation was to conduct a contaminant source investigation for each of the three areas at MAFB for the purpose of assessing (1) the presence or absence of contamination within the specified areas of the field survey; (2) the potential for migration of contamination (if found) within the specified areas of the field survey; (3) the extent and magnitude of contamination (if found) on MAFB property; and (4) the potential environmental consequences and health risks of migrating contaminants (if found) based on state and federal standards for these contaminants. The various aspects of the Phase II field investigation conducted by HART were detailed in the TOP prepared by HART in September 1986 and agreed upon by USAFOEHL and EPA personnel. The results of the Phase II investigation are conclusive and have provided HART with an adequate data base by which the SLA, the FTA and the EOD can be categorized. The categorization rationale is based on human health and environmental hazards and has been established under the DOD/IRP report format.

Category II sites are those requiring additional monitoring or investigation to quantify or further assess the extent of current or future contamination. All three sites at MAFB have been classified in this category.

A. The Sanitary Landfill Area

Further investigations at the SLA would consist of long-term ground water monitoring to assess future trends in potential contaminants in the ground water. Additional geologic investigations are not being recommended in this area as part of the Phase II investigation.

The investigation of the SLA conducted by HART was very thorough in (CL5060A/1)

its scope. It included drilling a total of ten test borings, installation of six shallow and four deep monitoring wells, sampling 13 ground water monitoring wells and four surface water sites, analyses of samples for a large variety of parameters and geotechnical analyses of subsurface soil samples.

As stated in Chapter IV, the potential for human exposure to SLA surface water is very low, based primarily on the low potential for migration. There is no potential for human exposure to SLA ground water based primarily on the slow migration rate of ground water and the non-existence of a drinking water supply in the glacial sediments or a ground water discharge point within a one-mile radius of MAFB sites. In addition, the SLA constituents of concern, sulfate, chloride, nickel and lead, are all naturally occurring substances; thus, their presence does not necessarily indicate an environmental hazard. Sulfate and chloride are commonly found in high concentrations in the MAFB area and lead was detected in only two ground water samples in concentrations slightly higher than the federal drinking water standard for lead.

Long-term monitoring at the SLA would consist of sampling the wells installed during HART's investigation and analyzing the samples for a reduced parameter list. Based on the constituents identified in Chapter IV, a suite of parameters would be chosen to monitor for changes in ground water quality. Parameters that best characterize the present constituents found in the ground water and that could be indicators of contamination would include common anions and PP metals. Upon initiation of a ground water monitoring program, semi-annual sampling of the wells would be adequate for the SLA.

A three-phased approach to monitoring is recommended. First, all the HART-installed wells will be sampled semi-annually for two years. The second phase will begin if, after two years, statistically the ground water chemistry has stabilized or decreased for the above-mentioned analytical parameters. If these conditions are observed, the parameter list and the number of wells sampled will both be decreased. The final (CL5060A/1)

phase consists of annual sampling for a period of two years; if, after that time, statistically the ground water chemistry has stabilized or decreased for the reduced list of parameters, sampling will be discontinued.

B. The Firefighting Training Area

The Phase II investigation of the FTA conducted by HART indicated that there is contamination of surface sediment in the FTA drainage ditch and of subsurface soil beneath the FTA. In addition, although no significant contamination of ground water was found, some volatile organic constituents were detected in the ground water sample obtained from monitoring well SW-9 and, thus, the potential for ground water contamination exists.

The Phase II investigation of the FTA conducted by HART was sufficient to assess the presence of contamination in the FTA and FTA drainage ditch; however, this investigation was not sufficient to determine the magnitude, extent, rate of movement and direction of movement of contaminants within the FTA and FTA drainage ditch. Thus, a more intensive Phase II effort is needed to improve the data base on which remedial action will eventually be based.

As stated in Chapter IV of this report, there is no potential for human exposure to contaminated subsurface soil or ground water based on the non-existence of drinking water supply or ground water discharge point within a one-mile radius of MAFB sites. However, the potential for human exposure to the FTA drainage ditch contaminants is moderate based on the exposure of the contaminants to the air and the surface water which occasionally flows in this ditch. HART believes that further contamination of this drainage ditch will only increase this potential for exposure and, thus, this situation requires attention.

Based on the FTA drawing No. 170-007 and estimates of the quantity and composition of the flow into the existing oil/water separator provided, (CL5060A/1)

the following have been determined to be contributing to the poor operation of the existing oil/water separator:

- Any sizable accumulation of solids in the grit chamber could hamper the flow through the orifice and out of the oil/water separator;
- The short duration, high volume flow into the oil/water separator is probably causing the water level in the oil/water separator to rise to a level higher than the intended design level. This could cause water to enter the oil chamber causing the previously separated fuel to mix with the water and thus be discharged. The high volume flow could also allow the oil/water mixture to flow right through the oil/water separator untreated; and,
- The process by which the fuel collected in the oil chamber is removed cannot be determined from available information. Unattentive inspection of the level of fuel in the oil chamber could cause fuel to overflow into the treated water and thus be discharged.

Hydrocarbons can be removed from the water using a number of methods, including:

- Oil skimmers, using a belt or similar device, are effective for high viscosity oils. The relative low viscosity of jet fuel makes this option unadvisable.
- Ultrafiltration processes the fuel/water mixture through a semi-permeable, microporous membrane, separating the fuel from the water. This method is very effective but is also extremely expensive and therefore not well suited to FTA application.

It is believed that the best option available would be to take out the chamber and bafflings in the existing oil/water separator and use the structure as an equalization/settling basin. A valve would be installed at the separator's outfall to regulate the flow into a new oil/water separator which could properly treat the oil/water mixture.

C. The Explosive Ordnance Disposal Area

The classification of the EOD as a Category II site is based on the potential for human exposure to EOD contaminants via direct contact with in-situ soil or contact with airborne particulates. At present only cadmium appears in subsurface soil samples in concentrations greater than the natural range found in soil. It is HART's opinion that the greatest potential for metals contamination is at the surface of the EOD where munitions were exploded. The Phase II investigation of the EOD involved only subsurface soil sampling.

Further investigation at this site would consist of taking several grab samples (three) of the surface soil and analyzing the samples for PP metals. In order to compare the metals concentrations in the EOD soil samples, a background sample should be taken from outside the EOD in an area free from human disturbances.

As the three areas of investigation at MAFB are classified as Category II sites, ground water monitoring well abandonment is not proposed. If, at some future point, it is determined that ground water monitoring wells are no longer needed, HART recommends the following well abandonment procedure: (1) remove the outer protective casing; (2) destroy the PVC well casing and screen by using a rotary drilling method; (3) continuously circulate drilling mud within the borehole to insure that all PVC cuttings are removed; and (4) tremie grout the borehole from the bottom with a bentonite-cement slurry. Grouting will prevent the borehole from acting as a conduit for ground water movement.

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